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Macro-Micro Feedback Links of Irrigation Water Management in Turkey

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Abstract

Agricultural production is heavily dependent on water availability in Turkey, where half the crop production relies on irrigation. Irrigated agriculture consumes about 75 percent of total water used, which is about 30 percent of renewable water availability. This study analyzes the likely effects of increased competition for water resources and changes in the Turkish economy. The analysis uses an economy-wide Walrasian Computable General Equilibrium model with a detailed account of the agricultural sector. The study investigated the economy-wide effects of two external shocks, namely a permanent increase in the world prices of agricultural commodities and climate change, along with the impact of the domestic reallocation of water between agricultural and non-agricultural uses. It was also recognized that because of spatial heterogeneity of the climate, the simulated scenarios have differential impact on the agricultural production and hence on the allocation of factors of production including water. The greatest effects on major macroeconomic indicators occur in the climate change simulations. As a result of the transfer of water from rural to urban areas, overall production of all crops declines. Although production on rainfed land increases, production on irrigated land declines, most notably the production of maize and fruits. The decrease in agricultural production, coupled with the domestic price increase, is further reflected in net trade. Agricultural imports increase with a greater decline in agricultural exports.

This paper—a product of the Sustainable Rural and Urban Development Team, Development Research Group—is part of a larger effort in the department to mainstream research on role of water resources in the economy. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The authors may be contacted at cakmake@metu.edu.tr, dudu@metu.edu.tr, ssirin@metu.edu.tr, x.diao@cgiar.org, troe@umn.edu, tsur@agri.huji.ac.il.

MACRO-MICRO FEEDBACK LINKS OF IRRIGATION WATER MANAGEMENT IN TURKEY[*]

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Acronyms

ARIP: Agricultural Reform Implementation Project

CES: Constant Elasticity of Substitution

CSE: Consumer Subsidy Equivalents

CGE: Computable General Equilibrium

DIS: Direct Income Support

DSI: State Hydraulic Works, Republic of Turkey

EU: European Union

FAO: Food and Agriculture Organization

IFPRI: International Food Policy Research Institute

GDRS: General Directorate of Rural Services

GDP: Gross Domestic Product

GTAP: Global Trade Analysis Project

LSCB: Lower Seyhan-Ceyhan Basin

OECD: Organization for Economic Co-operation and Development

PSE: Producer Subsidy Equivalents

QHS: Quantitative Household Survey

REC: Regional Environment Center

SAM: Social Accounting Matrix

SPO: State Planning Organization, Republic of Turkey

TACOGEM-W: Turkish Agricultural Computable General Equilibrium Model with water

TurkSTAT: Turkish Statistical Institute

UFT: Undersecretariat of Foreign Trade, Republic of Turkey

VA: Value-added

WUA: Water User Associations

WTO: World Trade Organization

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1 Introduction

The agricultural sector is an important sector in the Turkish economy. This sector is a major source of employment accounting for 27 percent of the total workforce, and providing employment for approximately 70 percent of the rural workforce. However, similar to other rapidly growing economies, the share of agriculture in Turkey's GDP has declined from 30 percent in the late 1970s to 9 percent in 2007. The agricultural sector, overall, appears to lag the rest of the economy in transforming to one with comparable per capita incomes. The growth rate of agricultural value-added is about one-fourth of the rest of the economy, which explains the declining share of agriculture in GDP over the past three decades.

Irrigation has a significant role in agricultural production. Irrigated agriculture forms about half of the crop production value. Diverse climatic zones, ranging from Mediterranean to semi-arid continental climate, and varied regional availability of water resources in Turkey, imply that water is a major factor in increasing productivity and decreasing volatility in agricultural production. Almost all export oriented crops (fruits and vegetables) and import-competing crops (cotton and maize) are heavily dependent on irrigation.

Development of water infrastructure gained momentum in the late 1960s. Irrigated area has more than doubled since then and the storage capacity of dams reached 140 billion m^3. Due to an increase in population, per capita water availability is down to roughly 1,700 m^3 per year. The irrigation sector is currently consuming about 75 percent of total water consumption which corresponds to about 30 percent of renewable water availability. The non-agricultural demand for water is increasing rapidly due to the fast pace of urbanization and industrialization. However, supply-management practices targeting mainly the development of irrigation infrastructure, have continued to prevail as the major determinant of irrigated agriculture.

Even with the rapid expansion of the irrigated area, reaching about 20 percent of the total area suitable for irrigation, the growth of the agricultural value-added has been dismal. The average growth rate is only 1.3 percent per annum in the past four decades, which is lower than the annual population growth rate. Turkey achieved almost full liberalization of trade in the manufacturing sector in the 1990s. High protection in agriculture has been maintained in order to sustain the self-sufficiency in major staples. As a result, transfers to agriculture that are provided mainly through price distortionary measures, reached 3-4 percent of GDP. This policy setting has prevented major structural changes in agriculture. The ineffective set of policy tools and their increasing burden on government expenditures led agricultural subsidization policies to undergo major changes in the latest structural adjustment and stabilization program at the start of the new millennium.

The macroeconomic stabilization program, incorporating tight fiscal and monetary policies, has affected the water related features of the Turkish agricultural sector. The agricultural subsidization reform program was never transformed into a reform in agricultural policies involving the water sector. A large number of already planned, yet incomplete irrigation development projects have been further delayed due to a lack of investable funds. The prevailing irrigation policy framework for infrastructure development has been revitalized as the economy recently recuperated, with the help of the program, without any emphasis on the more efficient use of water resources.

However, several developments will certainly increase the competition for water resources and may stipulate radical changes in water policies in the medium and long run. The rapid pace of urbanization may lead to changes in the inter-sectoral allocation of water. The Mediterranean basin is expected to be severely affected by the climate change. This may further increase the pressure on an already stressed water economy with severe implications for the agricultural sector. Growing interest by developed countries in biofuels, combined with increasing energy prices, is aggravating the impact of climate change. Although recent surges in prices of basic staples have begun to decline, the agricultural commodity prices, however, are expected to remain high compared to historical averages. In addition, the renewal of the WTO-Agreement on Agriculture and Turkey's candidacy for membership to the European Union (EU) will add new dimensions to the deliberations on agricultural and water policies.

Based on this background it is therefore necessary to evaluate the consequences of recent changes in the national and international scenes in the Turkish economy to provide better dialogue with policy makers and to develop proper policy responses.

The purpose of this study is to analyze the potential effects of surging agricultural prices, climate change, and urbanization in the Turkish economy by using an economy-wide model. The Walrasian CGE model for Turkey disaggregates the economy into 20 agricultural and 9 non-agricultural activities. The agricultural sector is further disaggregated into 5 regions. The model incorporates agricultural and non-agricultural water use with the differentiated irrigated and rainfed agricultural production activities at the regional level. Furthermore, a farm level model is used to estimate the shadow value of water in agriculture.

The following section presents an overview of water and agricultural sectors, followed by a brief review of relevant CGE applications. Section three provides a description of the CGE model used along with a summary of major data sources. This section also includes the farm level model used in the estimation of shadow prices for irrigation water. Various scenarios conducted with the CGE model are explained and the results are discussed in the fourth section. The final section is reserved for the conclusions and implications of the of the study.

2 Water and Agricultural Sectors in Turkey

Import substituting agricultural commodities (maize and cotton) and most of the exported products (fruits and vegetables) are irrigation intensive. Although Turkey is currently using only 40 percent of its available water resources, it is estimated that the country will reach its limits of available water within two decades due to increasing demands from all sectors. The estimates are based on the increase in the non-agricultural demand and the full development of 8.5 million hectares of “economically irrigable” land. Supply-side water policies still dominate, despite the widely pronounced pressures from the demand side. Over-abstraction of groundwater in some regions and over-use of surface water in others continue to be the major supply side issues in the water sector.

Due to the frequent economic crises from the past two decades, and the mismanagement of agricultural policies, structural change in Turkish agriculture has been delayed. The sector still dominates the rural economy, providing about 70 percent of total rural employment. The dualistic structure of production has all the basic traits of a developing economy. It has a dominant share of production concentrated in small holdings, while co-existing with commercial and mostly export-oriented producers.

2.1 Water Resource Availability and Use in Turkey

Turkey’s climate is moderated by both the Mediterranean and continental weather patterns which displays geo-climatic diversity when combined with a highly varied topography. The average annual temperature is 18-20^{o}C on the southern coast, 14-15^{o}C on the west coast, and fluctuates between 4 to 19^{o}C in the interior regions, depending on their distance from sea level. The annual average precipitation is 643 mm, yet varies from 250 mm in the central part to 3000 mm in the Eastern Black Sea region. Seventy-five percent of annual rain falls during the winter season. Annual rainfall is less than 500 mm in the inland Thrace and in the Eastern Anatolia regions. This diverse precipitation structure emphasizes the crucial importance of irrigation.

Generally, agricultural production is adversely affected by the shortage and inconsistency of rainfall during the growing season. Solar energy makes it possible to grow arid and semi-arid crops such as bananas and citrus. Moreover, it is possible to grow 2 to 3 different crops in irrigated areas that have crop growing seasons for a period of 270 days. However, some crops may be harvested before maturation, particularly in Eastern Anatolia with its 60 to 90 growing days. The southeast region has a very low humidity level. The coastal regions are humid with high precipitation rates. Inevitably, the topographic features are main factors shaping the distribution. The long-term annual evaporation rates indicate a high rate, particularly in the southeast region, which receives almost no rainfall during the summer, and reaches more than 2000 mm per year in the Southeastern region (Kanber et al., 2005).

The average annual precipitation of the country corresponds to a water potential of 501 km^3 per year, of which 274 km^3 are lost to evapotranspiration, 69 km^3 feed aquifers and 158 km^3 flow through the rivers to the sea or lakes. The gross total surface and ground water potential of Turkey amounts to 234 km^3 (Table 2.1).

Table 2.1. Turkey: Water Resources Potential and Use

Surface water	Groundwater	Total
Surface flow 158 km^3	Feeding groundwater 69 km^3	Mean annual precipitation 501 km^3 (603mm)
Surface runoff [a] 193 km^3	Recharge 41 km^3	Renewable water potential 234 km^3
Usable surface runoff[b] 98 km^3	Safe yield 14 km^3	Usable (net) 112 km^3
Consumption 31	Consumption 12	Consumption 43

Notes: [a] includes the contributions from underground (28 km^3) and from the neighboring countries (7 km^3);
[b] includes the usable flow of 3 km^3 from the neighboring countries.
Sources: DSI, 2008a.

The amount of surface water utilized for consumption purposes is in the range of 98 km^3 per year, including the contributions from the neighboring countries. According to the studies based on groundwater resources, the total safe yield of groundwater resources is estimated to be

14 km^3. Thus, the total potential available water resources from surface flow and groundwater would amount to 112 km^3 per year.

The country's surface runoff is unevenly distributed in both time and place, consistent with precipitation. Surface and ground water resources are limited in the Aegean, Thrace and Central Anatolia regions where the demand for water is higher than the rest of Turkey. The Aegean and Thrace Regions are highly urbanized and industrialized, and have soil resources suitable for irrigation. They have 10.5 percent of total surface water resources for the country while covering 19.3 percent of the entire area. Almost 30 percent of the total surface water for the country flows through two rivers, the Tigris and Euphrates (Table 2.2). An irregular regime of rivers requires reservoirs to regulate the water. It is estimated that 98 km^3 of surface water (51 percent of total surface water) can be consumed by technically and economically feasible projects. The actual utilizable water amount in Turkey is around 1,700 cum/person/year in 2007.

Table 2.2. Water Potential and Land Distribution by Basins

No	NAME	Area (km²)	Annual Basin Efficiency (l/s/km²)	Average Annual Flow (km^3)	Farming Land (1,000 ha)	Irrigable Land (1,000 ha)
1	Maritza-Ergene	14,560	2.9	1.33	1,095.3	1,078.0
2	Marmara	24,100	11.0	8.33	865.7	730.0
3	Susurluk	22,399	7.2	5.43	850.0	755.9
4	North Aegean	10,003	7.4	2.09	367.6	316.3
5	Gediz	18,000	3.6	1.95	667.2	623.4
6	K.Menderes	6,907	5.3	1.19	222.4	194.8
7	B.Menderes	24,976	3.9	3.03	1,044.3	907.4
8	West Mediterranean	20,953	12.4	8.93	437.4	406.6
9	Antalya	19,577	24.2	11.06	451.2	448.1
10	Burdur Lakes	6,374	1.8	0.50	251.4	249.5
11	Akarcay	7,605	1.9	0.49	364.4	359.9
12	Sakarya	58,160	3.6	6.40	2,814.3	2,681.1
13	West Black Sea	29,598	10.6	9.93	855.0	640.8
14	Yeşilırmak	36,114	5.1	5.80	1,617.2	1,401.2
15	Kızılırmak	78,180	2.6	6.48	4,049.8	3,761.1
16	Konya inland	53,850	2.5	4.52	2,182.8	2,134.9
17	East Mediterranean	22,048	15.6	11.07	438.3	327.8
18	Seyhan	20,450	12.3	8.01	764.7	714.0
19	Orontes	7,796	3.4	1.17	376.2	331.7
20	Ceyhan	21,982	10.7	7.18	779.8	713.7
21	Euphrates	127,304	8.3	31.61	4,293.8	4,111.3
22	East Black Sea	24,077	19.5	14.90	712.6	350.7
23	Çoruh	19,872	10.1	6.30	326.2	303.4
24	Aras	27,548	5.3	4.63	642.0	641.1
25	Lake Van	19,405	5.0	2.39	436.5	433.3
26	Tigris	57,614	13.1	21.33	1,148.2	1,137.6
	TOTAL	779,452	209.3	186.05	28,054.3	25,753.6

Source: DSI, 2007.

Sectoral consumption of water is presented in Table 2.3. Total human and utility water consumption is increasing steadily with population and income growth, totaling 6.2 km^3 per annum in 2004. The share of the population served by adequate water from the network connected at home or standpipes, reached 85 percent in rural areas, and 98 percent in urban areas. Annual water allocated to industry is about 4.1 billion m^3 supplied mainly from groundwater resources.

Table 2.3. Sectoral Water Use in Turkey

	Irrigation		Domestic		Industry		Total use (hm^3)
	Use (hm^3)	% of total	Use (hm^3)	% of total	Use (hm^3)	% of total	
1990	22,016	72	5,141	17	3,443	11	30,600
2000	29,300	75	5,800	15	4,200	10	39,300
2004	29,600	74	6,200	15	4,300	10	40,100
2023[a]	72,000	64	18,000	16	22,000	20	122,000

Note: Both the sectoral and total use varies depending on the source. We have presented the most recent findings.[a] Target mentioned in DSI (2007) implies full utilization of all usable water supplies.
Sources: SPO, 2007; DSI, 2007.

The total irrigated area was 5 million hectares in 2007 (Table 2.4) with 75 percent of the water allocated to irrigation. The irrigated area has already reached 60 percent of the total "economically irrigable" area of 8.5 million hectares. Water consumption per hectare amounts to more than 6,000 m^3. With respect to geographical regions used in this study, more than 40 percent of the total irrigated area is located in the Western region.

Table 2.4. Irrigation Development by Regions, 2007 (1,000 ha)

	DSI Region	Geo.R	DSI	DSI (GWIC)	GDRS	Farmers	Total
1	Bursa	W	58	5	31		95
2	Izmir	W	122	15	50	147	334
3	Eskisehir	W	77	26	68		171
4	Konya	C	190	187	163	95	635
5	Ankara	C	53	4	81		138
6	Adana	W	323	17	86	34	461
7	Samsun	C	88	20	67	51	226
8	Erzurum	E	84	16	96	154	350
9	Elazig	E	82	5	103	101	291
10	Diyarbakir	SE	43	0	20		63
11	Edirne	W	61	21	55	40	176
12	Kayseri	C	82	20	100	58	260
13	Antalya	W	80	6	21		107
14	Istanbul	W	0		6		6
15	Sanliurfa	SE	189	0	22		212
17	Van	E	66	1	67	43	177
18	Isparta	W	109	61	83	46	299
19	Sivas	C	23	1	35	73	132
20	K.Maras	SE	48	6	49		103
21	Aydin	W	199	18	59	130	406
22	Trabzon	E	13	1	35	23	72
23	Kastamonu	C	13	2	28	2	44
24	Kars	E	71		20	37	128
25	Balikesir	W	62	7	38		106
26	Artvin	E			11		11
	Total		2,136	438	1,394	1,034	5,001

Sources: DSI, 2008b ; GDRS, 2007 ; SPO, 2007.

The Western region is more populated and industrialized compared to the rest of the country. In addition, the seven river basins in this area are estimated to have already exceeded their long-term capacity utilization rates (World Bank, 2007). About 90 percent of irrigation methods depend on gravity systems with low water efficiency. Furthermore, the irrigation ratios of the schemes transferred by State Hydraulic Works (DSI) indicate that about 35 percent of the irrigated area are allocated to rainfed agriculture (Table 2.5). Unavailability of water is the top reason for the shift to rainfed agriculture (DSI, 2008a).

Table 2.5. Irrigation ratios of the areas transferred by DSI, 1999-2006

	Transferred Area (1,000 ha)	Irrigation Ratio (%)	Total Irrigation Ratio[a] (%)
1999	1,304	76	84
2000	1,609	66	76
2001	1,664	64	73
2002	1,687	68	79
2003	1,826	67	76
2004	1,861	69	79
2005	1,922	66	76
2006	1,976	65	77

Note: [a] Includes the area irrigated by farmers and the area outside the Scheme
Source: DSI, 2008b.

The significant role of irrigation for improving the performance of the agricultural sector is recognized in the Ninth National Development Plan for 2007-2013 (SPO, 2007). The Plan establishes the priority for the efficient use of water resources. The development of irrigation infrastructure takes precedence according to the targeted development toward 2023.

The transfer of operation and maintenance of the schemes developed by DSI is complete (Table 2.6). However, the sustainability of transferred schemes to the beneficiary is questioned in the recent development plan. The Plan recommends to develop participatory mechanisms together with the necessary legal provisions for efficient and sustainable use of soil and water resources.

Table 2.6. Management of Irrigation Schemes, 2007

	Number	Area (1,000 ha)
Developed by DSI	2048	2,573
Managed by DSI	86	82
Transferred to users' organizations	697	2,053
Transferred to ICs	1,290	438
Developed by GDRS and managed by the farmers	n.a	1,394
Developed and managed by the farmers	n.a	1,034
Total	n.a	5,001

Source: DSI (2008a)

Specific legislation regarding the water sector with comprehensive water management and defining water rights does not exist. Efforts in the past couple of years to enact a "water law" have yet to be successful. Sectoral priorities are set in the DSI law, but clear definitions of water entitlements are absent. DSI’s priority list begins with drinking and industrial water supply, continues with irrigation, power generation, flood control, and ends with navigation.

Pricing and cost recovery policies vary among sectors. There is almost no volumetric system for irrigation, whereas volumetric charges are common in domestic and industrial use. Almost all water users’ organizations determine the per hectare fee for the operation and maintenance based on expected operation and maintenance costs. The government has been reluctant to recuperate the investment costs.

Several legislations and regulations address specific issues, but they are far from forming an integrated framework for effective management of water resources. The existing laws and regulations are also far from defining appropriate water rights. Extended drought periods resulted in the full development of water resources in the western and central regions involving the transfer of water from irrigation to domestic and industrial use. This situation will increase the uncertainty of irrigation water allocation adversely affecting farmers’ welfare. The legislative arrangements should, at least, cover priority determination for the intra- and inter-sectoral (irrigation, municipalities, industry, recreation, fishery etc.) allocation of water, and a proper pricing policy to recover full supply costs of water from the beneficiaries.

Turkey is resistant toward making any radical changes in agricultural and water management policies. However climate change, surging agricultural commodity prices and rural-urban competition for water resources are expected to affect the resource allocation within agriculture. Further these factors will also have significant implications for the inter-sectoral allocation of resources. The impact on producers and consumers will be diverse, thus it is important to consider the economy-wide feed back effects of the conducted scenarios to design and prioritize proper policy responses for the agricultural and water sectors.

2.2 Overview of the Agricultural Sector in Turkey

The average annual growth rate of the non-agricultural value-added in Turkey during the past four decades (1968-2006) was 5.1 percent. The growth of the agricultural sector was limited to 1.3 percent per year. The growth rates of agricultural production for different decades are presented in Table 2.7. Relatively high growth decades are followed by stagnant periods. The only exception occurred in 2002-2006, following the implementation of the structural adjustment program. With stable policies and favorable climatic conditions the sector grew 2 percent annually during this period. Production declined in 2007 due to an unprecedented drought.

Table 2.7. Agricultural value-added: growth and share, 1968-2007

	GDP series	
Period/year	1987 base	1998 base
Average annual growth in agriculture (percent)		
1968-2006	**1.31**	
1968-1979	1.37	
1979-1989	0.57	
1989-1999	1.61	
1998-2006	**0.88**	**1.23**
1998-2007		**0.24**
2002-2006	2.00	2.04
2002-2007		0.10
Share of agriculture in GDP (percent)		
1968	33.3	
1978	23.4	
1988	18.2	
1998	13.7	12.1
2006	11.0	9.7
2007		8.6

Source: calculated from TurkSTAT (2008)

Share of agriculture in GDP declined drastically by roughly 20 to 25 percentage points, due mostly to higher growth in the rest of the economy. Recent population census in 2007 indicated that population in Turkey grew by 1.9 percent per year during the same period.

The structure of the agricultural production in Turkey has many of the characteristics of a developing economy. The share of agriculture in total employment is still around 27 percent. The average land and herd size per farm household are small. Farms in Turkey are generally family-owned, small, and fragmented. The average cultivated area per holding was about 5.2 ha in 1991, and it increased to about 6 ha in 2001. About 85 percent of holdings, on 41 percent of the land, were smaller than 10 ha. 15 percent of holdings were from 10 to 50 ha, and they cultivated almost half of the cultivated land (TurkSTAT, 1994, 2004b). The average size increases from west toward southeast due to the climate and fertility differences. According to the agricultural surveys, the proportion of the irrigated land in total cultivated land increased from 14 percent in

1991, to 20 percent in 2001. The share of irrigated land is much higher in the west than elsewhere in Turkey. One third of the holdings smaller than 1 ha have access to irrigation. The distribution of agricultural land remained skewed with a Gini coefficient of 0.60. A slight tendency towards the medium ranges from smaller sizes are observed from 1991 to 2001 (TurkSTAT, 1994, 2004b).

Of the 26 million ha of cultivated land (TurkSTAT, 2006), field crops have occupied slightly over 85 percent of the cultivated area since 1985. The share of the vegetable area is about 3 percent, but has been increasing steadily. Orchards occupy 10 percent of the cultivated land. Land left to fallow is about 5 million hectares. The value composition of the agricultural production diverge drastically from the use of the cultivated land. The weight of crop production has been dominant in the total value of production. The value of livestock products makes a quarter of the total value (TurkSTAT, 2006b). The structure of production is far from reflecting the policy weights that seem to underlay government intervention in agriculture. The policies are generally targeted towards cereals and industrial crops, whereas vegetables and fruits have relatively smaller importance apart from some specialty products. However, the share of fruits and vegetables in total value is slightly over 40 percent. Protection and government support of animal products have not been sufficient to counterbalance the additional costs of feed due to interventions in the cereals. Turkish consumers end up paying higher prices compared with the average meat and milk prices in the EU.

The employment creation capacity of the economy has always been problematic, mainly because the growth in the country's capital stock has not been commensurate with the rapid expansion of the labor force. Despite improvements in economic indicators since 2002, the unemployment rate remains stagnant at around 10 percent. The rural unemployment rates, both male and female, are the major contributing factors in the stickiness of the overall unemployment rate. The declining trends in the rural labor force participation rates and the share of agriculture in rural employment, combined with increasing rural unemployment rates, signal the start of a major transformation in the use of labor in agriculture. However, agriculture is still helping to overcome the chronic nature of unemployment in Turkey. It eases the detrimental effect of the lack of human capital on growth rates of the labor force, and the inability of the non-farm sector to pull even more labor from agriculture. The illiteracy in agricultural employment is significantly higher compared to the rest of the economy (Çakmak and Akder, 2005) which contributes to the difficulty of pulling labor out of agriculture. Due to the small average farm size, agricultural employment has a relatively large share in total employment. The sector provides employment for almost all females within rural areas with almost an 85 percent share in rural employment. However, like other rapidly growing economies, the share of agricultural employment in overall employment, as well as absolute agricultural employment, are steadily declining. Agricultural employment was 6 million in 2007 compared with 9 million in the early 1990s.

Turkey may be considered a perfect example of the mismanagement of agricultural policies particularly after reforms that took place in the mid-1980s. Agricultural policies involved mainly transfers and were not aimed at improving productivity. The transfers to producers occurred mostly from consumers through support purchases for major crops backed by high tariffs.[1] Until the onset of the structural adjustment program in 2001, transfers to farmers from the taxpayers were not substantial but were accompanied by huge financial costs. Most of the budgetary transfers to farmers were not planned causing high financial losses for state banks. The financial burden was further amplified by the "duty losses" of state economic enterprises through support purchases and revolving credit lines to the agricultural sales cooperatives' unions. The Agricultural Reform Implementation Project (ARIP) began in 2001 as part of the second phase of the structural adjustment program.

Total producers' subsidy in Turkey showed a significant increase prior to the start of structural adjustment program in 1999. The contribution of agricultural policies to the farmers' revenue increased from USD3.4 billion to USD8.0 billion during the 1990s (OECD, 2006). The general effects of ARIP were significant with a sudden drop in the support to agriculture in 2001. The state intervention in the output markets was severely restricted in 2001, coupled with the delayed implementation of direct income support. The domestic market has been adjusting fast. The market price support provided by the border measures has picked up again in 2002 and it has remained high ever since.

The share of total agricultural support in GDP was 6 percent in the late 1990s. It declined to 3.8 percent in 2005, but is still one of the highest (as a share of GDP) among OECD member

[1] Turkey accomplished significant liberalization of trade in industrial products. The liberalization in the agriculutral sector has been proceeding at a slow pace. Except for the primary commodities extensively used as intermediate inputs in export oriented manufacturing industries (cotton, raw hides and skins), Turkey has high levels of protection in meat, dairy products, sugar and basic cereals.

countries. The rate of consumer subsidy equivalents (CSE) is back to the pre-crisis level in 2005 of 21 percent. The distribution of transfers to producers has not changed much since the 1980s, except in 2001. The share of market price support in producer subsidy equivalents (PSE) remained around 80 percent. The remaining burden falls on the taxpayers. Significant shifts between policy tools occurred in budgetary support. Input price intervention almost disappeared, instead area based direct income support (DIS) contributed 15 percent of support to producers.

Concerning the trade policy, high tariff levels for the major commodities and non-tariff protection stayed intact until the recent surge in agricultural prices in 2006 and 2007. Considering the fact that the share of food expenditures for the average consumer is still more than 30 percent, the government tried to decrease the wedge between domestic and world prices by granting duty free imports mostly to the state procurement agency. The funds used for DIS payments have been directed more towards the commodity specific deficiency payments.

The state of agriculture both in terms of its growth pattern and overall structure of production makes it necessary to evaluate the economy-wide implications of surging world prices in Turkey.

3 The Modeling Framework

The application of computable general equilibrium (CGE) modeling analysis on water management issues is relatively new in the literature. CGE Modeling has made possible the exploration of economy-wide effects of water policy. CGE models dealing with water issues can be broadly grouped into five categories according to their research questions.

The first group of models deals with the competition of different sectors or alternative user groups for water. Seung et al. (2000) models the welfare effects of using water in irrigation or for recreational purposes. Briand (2004) on the other hand, introduces drinking water demand and analyzes the competition between drinking and irrigation water.

The second group of models investigates the cost recovery and pricing based water conservation policies. Beritella (2006) for example analyzes the global and national level economic impacts of water transfer projects in China. Valezquez (2007) analyzes the effects of the increase in the price of irrigation water on the efficiency of the water consumption in agriculture and the possible reallocation of water to the other sectors. Letsoalo et al. (2005) test the ‘triple dividend hypothesis’ to see if water price policies can bring about reduced water use, more rapid economic growth and a more equal income distribution simultaneously. He concludes that it is possible to achieve triple dividends through water pricing.

A third group of models is related to the facilitation or liberalization of irrigation water trade. In fact, almost all relevant papers in the literature can be included in this group. However, some studies are missing the necessary constructs to simulate water markets. Goodman (2000) shows that water trade can replace construction of new irrigation facilities by increasing efficiency. Peterson (2004) shows that the impact of water shortages can be compensated by increasing water trade. Dywer (2005), extends the analysis of Peterson (2004) to urban water usage. Tirado (2004) shows the effect of having a market for water rights between urban and agricultural sectors and argues that such a market would benefit both user groups. Kohn (2003), on the other hand, investigates the effect of international water trade by using a Heckser-Ohlin framework.

The last group of models attempt to combine CGE models with other types of models. Finoff (2004) introduces a bio-economic model based on general equilibrium approach while Smajgl et al.(2005) integrates theoretically agent-based modeling with CGE models. Lastly, some recent models began to analyze the micro-macro linkages in water issues with CGE models. Roe et al. (2005) and Diao et al. (2005, 2008) use both top-down (trade reform) and bottom-up (farm water assignments and the possibility of water trading) linkages. They concluded that trade reform (top-bottom or macro to micro linkage) has a higher effect compared to water reform (bottom-up or micro to macro linkage).

Several CGE models were developed for Turkey aimed at analyzing macroeconomic issues in the 1990s. A selected list may include Harrison et al. (1993, 1996), Yeldan (1997), Karadag and Westaway (1999). Starting in the early 2000s, efforts devoted to develop CGE models for Turkey have increased. However, these models are also geared toward macro and trade analysis with aggregated agricultural sector.

CGE models targeted to analyze the issues of Turkish agriculture are relatively few. Agricultural CGE models on Turkey generally seek to address trade liberalization and reform issues. The first serious attempt to analyze the Turkish agriculture by using a CGE model is Cakmak et al. (1996), where a partial equilibrium model is coupled with a CGE model. The CGE model had an aggregated agricultural sector together with three non-agricultural sectors. The dynamics in the agricultural sector were captured via the sectoral model. Further, the simulations related to the agricultural sector were done via the sectoral model, while the CGE simulations aimed to evaluate the effects of macroeconomic shocks and to reveal the role of the agricultural sector in the macroeconomic adjustment processes.

Diao and Yeldan (2001) developed a general equilibrium model of the Turkish economy with a detailed agricultural sector. They have used an inter-temporal CGE model to analyze the effects of global agricultural trade liberalization. Turkey is one of the regions in the model along with Morocco and other Middle Eastern countries. Agriculture is disaggregated into five subsectors; grain crops, vegetables and fruits, sugar, other agriculture and animal products. Their main conclusion was in favor of trade liberalization.

Dogruel et al. (2003) used a CGE model to explore the feasible alternatives of agricultural reform and links between “the public sector fiscal balances, accumulation patterns, dynamic resource allocation, and consumer welfare under a medium-long-term horizon”. The model consists of six sectors. Agriculture is modeled as an aggregate sector. Land is not included in the model as a production factor. Hence the model is not a “real” agricultural model though the question of the research is agricultural.

The intention of the CGE model developed by Çırpıcı (2008), is to analyze water management issues in Turkey. The model has 9 sectors, incorporating 4 factors of production. Agriculture is not disaggregated. Water enters agricultural production as land and water aggregate calibrated with a Leontief function. The Cobb-Douglas production function is used in the non-agricultural production. The model lacks the regional and sectoral detail in agricultural production.

Studies using CGE models to conduct agricultural policy analysis incorporate agriculture as an aggregate sector both in production and consumption. Thus the policy simulations can not take into account possible interactions within the agricultural sector. The model used in this study namely, Turkish Agricultural Computable General Equilibrium Model with Water (TACOGEM-W), incorporates enriched treatment of agricultural production and consumption activities.

TACOGEM-W is the first attempt that exclusively models Turkish agriculture both in regional and sectoral details. The model utilizes the results of a farm level model developed for a micro region to estimate the shadow price of irrigation water. Hence, the rent created by the low prices for irrigation water is included in the model, linking the micro and macro aspects of irrigation water management.

3.1 Structure of the Agricultural Computable Equilibrium Model for Turkey

TACOGEM-W is a Walrasian CGE model that includes the behavior of the three main sectors in the Turkish economy: the production activities, the institutions, and the foreign sector. In order to study the impact of a range of policy simulations, TACOGEM-W further disaggregates the economy into 20 agricultural and 9 non-agricultural activities. Agricultural activities are categorized by field crops, livestock, fishing and forestry (classified as ‘other agriculture’). Non-agricultural activities include mining, consumer manufacturing, food manufacturing, intermediates and capital goods, electricity and gas, water, construction, private services and government services. Table 3.1 provides a break-down of the Turkish GDP in activities for the year 2003. Accordingly, about 12 percent of gross output was devoted to agriculture, about 25 percent to industry, and the remaining 63 percent to services.

Table 3.1. Gross national product by kind of activity, 2003

	Product in current prices	
ISIC, Rev. 2	Value (Billion TL)	Sector share (%)
Agriculture	42 126 246	11.8
Agriculture and livestock	39 550 179	11.1
Forestry	1 268 139	0.4
Fishing	1 307 928	0.4
Industry	88 813 240	24.9
Mining and quarrying	3 858 087	1.1
Manufacturing	71 910 797	20.2
Electricity, gas, water	13 044 356	3.7
Trade	71 329 760	20.0
Transportation and communication	53 846 171	15.1
Financial institutions	17 884 644	5.0
Ownership of dwelling	14 653 025	4.1
Business and personal services	12 429 089	3.5
(Less) Imputed bank service charges	7 911 747	2.2
Government services	36 561 477	10.3
Private non-profit institutions	3 610 383	1.0
Import duties	13 758 630	3.9
GDP (in purchasers’ value)	359 762 926	100.9
Net factor income from rest of the world	-3 082 038	-0.9
GNP (in purchasers’ value)	356 680 888	100.0

Source: TurkSTAT (2005)

By examining the employment structure in the Turkish economy as of 2003, we see that 34 percent of total employment is still in agriculture, generating only 12 percent of total income, as implied in the previous table.

Table 3.2. Employed persons by branch of economic activity, 2003

	(000)	Share (%)
Total	21 148	100
Agriculture, forestry, hunting and fishing	7 165	33.9
Mining and quarrying	83	0.4
Manufacturing	3 663	17.3
Electricity, gas and water	99	0.5
Construction	965	4.6
Wholesale and retail trade, restaurants and hotels	4 052	19.2
Transportation, communication and storage	1 022	4.8
Finance, insurance, real estate and business serv.	738	3.5
Community, social and personal services	3 359	15.9

Source: TurkSTAT (2005)

Among the agricultural activities, field crops and livestock are further disaggregated into production in four main regions and one micro region of the country, as given in Figure 3.1: West, East, Central, Southeastern, and the micro-region, LSCB (Lower Seyhan-Ceyhan Basin). Fishing, forestry and non-agricultural activities remain at the national level. Geographically, The West region includes Istanbul, Marmara, Aegean and the Mediterranean regions (except for Adana and Osmaniye provinces), the region East includes Northeastern Anatolian, Mid-eastern Anatolian and Eastern Black Sea Regions, Central region includes Western Anatolian, Mid-Anatolian and the Western Black Sea, and the LSCB micro region includes Adana and Osmaniye provinces. Figure 3.1 depicts the geographical distribution of the regions defined in the SAM. Appendix Table A.1 and Table A.2. give a list of regions and the provinces included in the model.

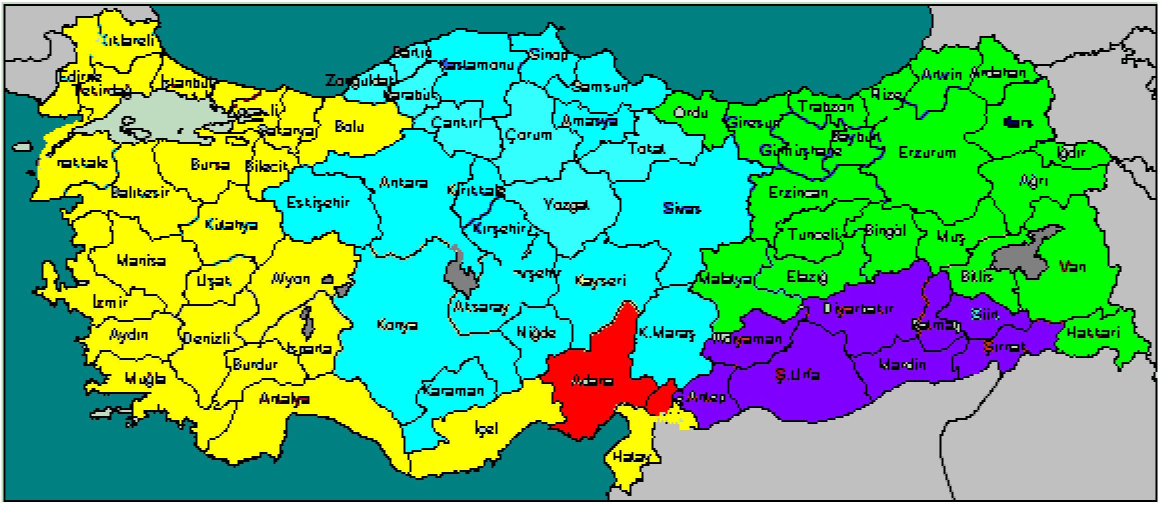

Figure 3.1. The five regions defined in the SAM

A considerably large share of almost all agricultural production is concentrated in the western parts of the country, based on the agricultural production value data from 2003 (TurkSTAT, 2003). 51 percent of the production value of all crops is produced in the western region, while up to 65 percent of all production value generated from fruits and vegetables are produced in the western region. Nevertheless, some regions are prominent in specific crops: for example, 46 percent of all cotton is grown in the Southeastern Anatolian region, while 7 percent of all cotton is produced solely in the Adana-Osmaniye region. Furthermore, the Central region provides the majority of sugar beet production in Turkey with 63 percent of the total.

Table 3.3.Share of regional production value in national production value, 2003 (Agriculture only)

	WEST	CENTRAL	EAST	SE_ANATOLIAN	LSCB
TOTAL CROPS	0.51	0.25	0.08	0.11	0.05
FIELD CROPS					
Wheat	0.34	0.36	0.07	0.15	0.08
Barley	0.30	0.40	0.10	0.19	0.01
Maize	0.41	0.14	0.09	0.05	0.30
Other grains	0.52	0.42	0.04	0.01	0.01
Pulses	0.28	0.35	0.07	0.29	0.01
Tobacco	0.73	0.15	0.04	0.09	0.00
Sugar beet	0.23	0.63	0.13	0.00	0.00
Cotton (raw)	0.47	-	0.00	0.46	0.07
Oil seeds	0.77	0.08	0.01	0.02	0.13
Potatoes	0.29	0.53	0.16	0.00	0.01
VEGETABLES	0.65	0.20	0.03	0.07	0.04
FRUITS	0.64	0.16	0.09	0.07	0.04
NUTS	0.31	0.18	0.30	0.21	0.00
OTHER CROPS	0.46	0.44	0.02	0.06	0.02
ANIMAL PROD.	0.51	0.25	0.17	0.05	0.02
Milk	0.38	0.28	0.26	0.06	0.02
Cattle meat	0.50	0.27	0.17	0.06	0.00
Other big animal meat	0.55	0.18	0.08	0.18	0.02
Poultry and eggs	0.74	0.22	0.03	0.01	0.01
Other animal prod.	0.38	0.19	0.34	0.06	0.03

Source: TurkSTAT (2003)

The institutions sector (or, block) of the economy includes households, the government and the Water User Associations (WUA). Households are disaggregated into rural and urban households. Rural households are further disaggregated among each other according to their geographical location. Hence in TACOGEM-W, there are five rural household and one urban household type (urban household defined at the national level). Households earn income from factors of production (land, labor, capital), engage in expenditures on various commodities, save, and also pay taxes to and receive transfers from the government. The identification of rural household types links to the variation in resource endowments common to agriculture.

The government collects tax revenue from numerous sources: production, sales, households, and imports. The government uses these funds for purchases of goods and services at the respective markets and makes transfers to households, and engages in public savings.

Regional activities of field crops , in addition to land, labor and capital, use water as an input in production. These activities also make payments to WUAs in their respective regions. These water charges are income earned by the Water User Associations. In TACOGEM-W, it is assumed that this water income collected in each region is simply transferred back to the respective rural household in a lump-sum.

In Turkey, as of 2003, 87 percent of all agricultural land is devoted to cultivation of field crops (Table 3.4). About 23 percent of all agricultural land is under irrigation, and similarly, 22 percent of all field area sown is irrigated (Table 3.5).

Table 3.4. Agricultural land use, 2003

	(000 Hectare)	Share (%)
Agricultural land	26 027	100
Cultivated field area	22 554	86.7
Area sown	17 563	67.5
Fallow land	4 991	19.2
Area of vegetable gardens	818	3.1
Area of vineyards	530	2.0
Area of fruit trees	1 500	5.8
Area of olive trees	625	2.4

Source: TurkSTAT (2005)

Table 3.5. Irrigated versus rainfed land use, 2001 (hectares)

	Total area	Irrigated	Not irrigated
Total area	15,322,010	3,505,749	11,816,261
Area sown	12,253,912	2,716,529	9,537,383
Fallow land	2,737,560		2,737,560
Vegetable and flower gardens	371,512	271,009	100,503
Fruit orchards and other permanent crops	1,757,962	455,590	1,302,372

Source: TurkSTAT (2004b)

For 38 percent of the irrigated area, wells are the most important source of water (Table 3.6). The second most important source of irrigation is streams, followed by the use of dams. The most common method to supply water to crops is flooding, which accounts for 84 percent of the area irrigated (Table 3.7).

Table 3.6. Irrigated area by irrigation source, 2001

	Area (hectare)	Share (%)
Total irrigated land	3,505,749	100
Well	1,316,709	37.6
Spring	352,403	10.0
Stream	1,003,856	28.6
Lake	67,666	1.9
Artificial lake	99,715	2.8
Dam	556,346	15.9
Other sources	109,052	3.1

Source: TurkSTAT (2004b)

Table 3.7. Irrigated area by irrigation system, 2001

	Area (hectare)	Share (%)
Total	3,505,749	100
Flooding irrigation	2,865,356	84.1
Sprinkler irrigation	582,414	17.1
Drip irrigation	57,978	1.7

Source: TurkSTAT (2004b)

To construct the regionalized SAM for the year 2003 (please see Table A.3 for a more aggregated version of the SAM for the year 2003), we combine various data from 2003 Agricultural Structure-Production, Price, Value Statistics (TurkSTAT, 2003); Telli (2004); 1998 Input Output Structure of the Turkish Economy (TurkSTAT, 2004a); 2003 foreign trade statistics by Undersecretariat of Foreign Trade (UFT Website); TurkSTAT 2002 Household consumption expenditures and income survey statistics (TurkSTAT Website), ARIP Quantitative Household Survey (QHS) commissioned by the Treasury and implemented by the G.G. Consulting et al. (conducted in 2002 and 2004), and the Turkish SAM for 2001 developed by GTAP. This regionalized SAM includes information on the regional level employment of labor and capital as well as intermediate input use by crop, along with water charge and irrigated versus rainfed land rents by crop. Employment of capital, labor and data on intermediate input use are also entered for activities at the national level in the SAM. Detailed income, consumption and saving information for the five-types of households (urban, and four rural) are included in the institutions block of the SAM. Also included in the institutions block are the data on government consumption, net tax receipts, and public savings, along with the WUAs' accounts. Finally, import, export and tariff data concerning the EU-25 and the rest of the world constitute the foreign sector block of the SAM (the foreign trade partners to Turkey are the 25 European Union countries and the rest of the world). These detailed data are used to obtain the parameters for TACOGEM-W.

The algebraic structure of TACOGEM-W is based on the CGE model developed by Lofgren, et al. (2002). The entire sequence of mathematical equations that define TACOGEM-W is provided in Appendix B. Main characteristics of the TACOGEM-W include:

- Production technology in each activity is defined by a CES function of value added and aggregate intermediate input use;
- Value added in each activity is given by a CES production function of factors used (labor, capital, irrigated land, rainfed land and water, if applicable);
- Aggregate domestic output is distributed among domestic use and exports (EU and rest of the world) by a Constant Elasticity of Transformation function;
- Composite output supply (of domestic supply and imports from the EU and the rest of the world) is of Armington form;
- All producers take factor and commodity prices as given, and are all profit maximizers;
- Urban and rural household types in each region have a simple consumption pattern in the sense that they devote a fixed share of expenditures on each consumption item. Each household type has a different consumption pattern depending on household income and savings. Implicitly in this structure, households are assumed to minimize expenditures on consumption, taking as given the price of each commodity.
- Households derive income from factors of production depending on the household type. Urban households earn income from labor services and capital rent, while each rural household earns income from services of labor and capital, as well as land rents (irrigated and rainfed) and income from the WUA's via transfers from government;
- The government also has a fixed consumption pattern in the sense that it devotes a fixed share of expenditures on each commodity. The government derives income from various types of taxes (import, export, production, sales, etc.) and also saves. The government in this model also acts as an intermediary between the WUA's and the rural households in the sense that the water charges collected from agricultural producers by the WUA's are then distributed to rural households in their respective regions by the government.

- In TACOGEM-W, each commodity and factor market clears, implying that there is no unemployment of any factor of production, including labor. At the base year of 2003, all prices for commodities and factors are given exogenously, implying that the relevant markets are assumed to clear at these prices. But the prices of commodities and factors are expected to respond endogenously to any shock given to the economy, via the policy scenarios given below.
- The model closure is the standard Walrasian closure through investment and saving balance.

3.2 The Farm Model: Structure and Results[2]

Econometric or programming approaches are commonly used in the literature to estimate water demand in agriculture. However, econometric estimation of water demand is limited because of the lack of necessary data. Furthermore, even if the data is available, quantity and price variations are typically small, leading to inaccurate estimations due to large variances. The programming approach uses the concept of shadow prices in order to derive the water demand.

The programming approach starts by assuming that water is provided free of charge but is constrained at the level *x*. The approach, in fact, asks the question how much farmers are willing to pay to relax the water constraint by Δ units.

Suppose that, in addition to water, crop production involves k inputs $z = (z_1, z_2 ... z_k)$ that can be purchased at the prevailing market prices $r = (r_1, r_2 ... r_k)$ with a perfectly elastic supply curve and m primary inputs (e.g., land) $s = (s_1, s_2 ... s_k)$ that are available free of charge in limited quantities $b = (b_1, b_2 ... b_m)$. Moreover, let us denote the production function by $F(q, z, s)$. Note that, here, *q* is input of water used in the production. In this situation, the decision problem for the producer can be expressed as (Tsur, Dinar, Roe, and Doukkali, 2004, p.5):

$$\pi(x, b, p, r) = \max(q, z, s)\left(pF(q, z, s) - r_1 z_1 + r_2 z_2 + ... + r_k z_k\right)$$

subject to	$q \leq x$	(water constraint)
	$s \leq b$	(land, family labor etc constraints)
possibly other,		(non-negativity constraints)

where, *x* is the water constraint, *p* is price of crop, *z* represents the purchased inputs (such as fertilizer, hired labor, machinery, pesticide, etc..), *q* is water input, *s* represents fixed inputs (such as, land, family labor, capital, etc.).

For nonlinear production functions $F(q, z, s)$, the above constrained optimization constitutes a non-linear programming problem. A special case arises when the function *F* admits

[2] The authors ackowledge the contribution of Ozan Eruygur in Sections 3.2 and 3.3.

the Leontief form, and in this case, the constrained optimization reduces to a linear programming problem. As a result, a simple model can be expressed as follows:

$$\max \pi = L_1\pi_1 + ... + L_n\pi_n$$

subject to

Shadow Prices, λ

$$a_{11}L_1 + a_{12}L_2 + ... + a_{1n}L_n \le x \qquad \text{(water constraint)}$$

$$L_1 + ... + L_n \le L \qquad \text{(land constraint)}$$

$$a_{21}L_1 + a_{22}L_2 + ... + a_{2n}L_n \le b \qquad \text{(labor)}$$

other constraints, non-negativity, rotation, etc..

where π_j is crop *j*'s profit per hectare with $j = 1,2,\ldots,n$ and is calculated from data and L_j is crop *j*'s land allocation which is the decision variable. Note that the shadow price for water is λ, land is μ_L and family labor is μ_f.

In this setup the shadow price for the water constraint is the value of the marginal product of irrigation water. In order to get the derived demand for irrigation water, we should change the water constraint from zero when irrigation water is not binding (Tsur et al, 2004, p.6). Notice that this setup is the model structure most generally used in order to estimate the derived demand for water in the literature. Algebraic Details of the model can be found in Appendix C.

3.3 Linkage between the Farm Model and TACOGEM-W

The farm model is used to estimate the shadow value of water in agricultural production. The formula for the derived demand is found to be

$$Q_w = 18.3P^{-0.47}$$

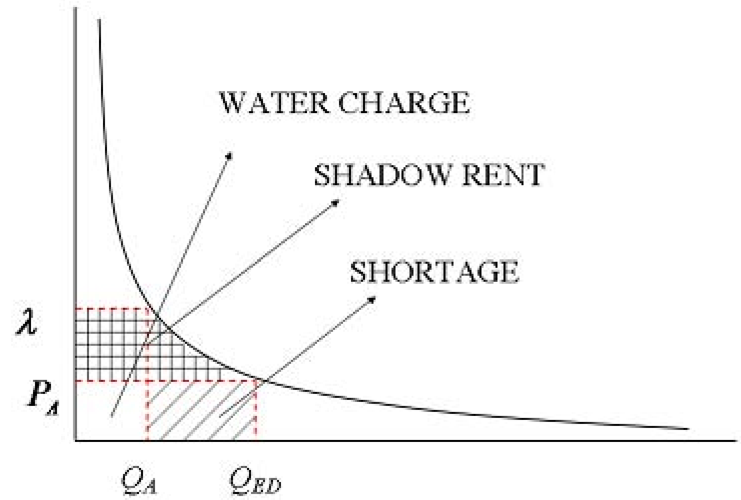

Figure 3.2. Shadow rent

Consider Figure 3.2. Q_A is water demand at the shadow price. Q_{ED} is the demand at the actual price level. In this setup, shadow rent is the difference between the farmers' surplus at λ and P_A, shown by the shaded are. This area can be calculated by

$$SR = (\lambda - P_A)Q_A + \int_{P_A}^{\lambda} 18.3P^{-0.47}$$

$$SR = (\lambda - P_A)Q_A + 39\left(\lambda^{-1.47} - P_A^{-1.47}\right)$$

then since

$$\lambda Q_A = \lambda \frac{P_A Q_A}{P_A}$$

$$\lambda Q_A - P_A Q_A = SR - 39\left(\lambda^{-1.47} - P_A^{-1.47}\right) = \lambda \frac{P_A Q_A}{P_A} - P_A Q_A$$

$$SR = P_A Q_A \left(\frac{\lambda}{P_A} - 1\right) + 39P_A^{-1.47}\left(\left(\frac{\lambda}{P_A}\right)^{-1.47} - 1\right)$$

the shadow rent (*SR*) can be calculated by merely using the ratio of shadow price to actual price, the actual payments made for irrigation and actual price. From the data used to form the SAM for TACOGEM-W $P_A \cong 2.5$ TRY *per* $1000\,\mathrm{m}^3$ and $Q_{ED} \cong 88{,}800$ Million m^3. Farm model yields $\lambda \cong 5$ TRY *per* $1000\,\mathrm{m}^3$ and $Q_A \cong 78{,}000$ Million m^3. Substituting these values yields,

$$SR = 2.5 \times 78,000,000 \times \left(\frac{5}{2.5} - 1 \right) + 39 \times 2.5^{-1.47} \times \left(\left(\frac{5}{2.5} \right)^{-1.47} - 1 \right)$$

$$= 210,600,000 - 6.48$$

Hence one can ignore the $39 P_A^{-1.47} \left(\left(\frac{\lambda}{P_A} \right)^{-1.47} - 1 \right)$ term in the calculation of shadow rent. Then,

$$SR = P_A Q_A \left(\frac{\lambda}{P_A} - 1 \right) = P_A Q_A \left(\frac{5}{2.5} - 1 \right) = P_A Q_A$$

which implies that shadow rent for water is twice the actual payment made to water. Under these findings we added this shadow rent to the payments made to irrigation water as a factor of production.

4 Empirical Results

Simulations reported in this study are selected according to their relevance and importance in water management issues, as well as agricultural policies of Turkey in the medium to long run. The first set of simulations involve the effects of changes in world agricultural prices; the second set of simulations examine the impacts of rural to urban water reallocation within each region; and the last set of simulations analyze the impact of climate change on agriculture.

World agricultural prices began to rise in 2005 (OECD and FAO, 2008). The level of the price increase has caused international concern, because of its effect on those with low income. International institutions, including the OECD, EU, FAO, IFPRI, United Nations and the World Bank have called attention to the adverse affects of the increases in prices. The recent surge of prices in agricultural commodities has immediately affected low income consumers in Turkey. The share of food expenditures in total expenditures is near 40 percent in the lowest quintile (TurskSTAT, 2006). Although the prices are expected to decline from peaks achieved in 2007, the real prices of basic staples are expected to be higher than historical averages in the medium run. This situation may stimulate agricultural production and increase the income for farmers. It may also change the cropping pattern and increase the pressure on water resources. Consumers on the one hand have been and will continue to be adversely affected by the increase in prices. These interdependencies ask for a modeling structure which will take into account the economy wide effects of the increase in prices.

The severe drought in 2007 brought focus on the increasing competition for water between urban and rural areas. Metropolitan municipalities, mainly in the Western part of the country, have already begun to develop and implement projects to bring water from rural areas to the cities. This has increased the stress on irrigation water resources. The model structure reveals the possible effects of carrying on and extending this transfer policy on crop production pattern and other key economic variables.

Finally, climate change scenarios have also attracted considerable attention in Turkey. Climate change is expected to reduce precipitation in most parts of Turkey depending on the region. Reduced precipitation is anticipated to have severe adverse effects on the rainfed agriculture. Even the irrigated agricultural production will demand more water as a result of reduced precipitation. Combined by the increase in the urban demand, the pressure on water resources will certainly increase. The discussion on this topic is generally limited to the price (and hence production) effects of climate change. We attempt to simulate the effects of the anticipated climate change by shocking the yields of various crops to see the economy wide effects. The following section presents the aggregate results for the scenarios. A thorough discussion on the design of the scenarios together with the obtained results can be found in the subsequent sections.

4.1 Aggregate Results of the Simulations

World price increase is simulated by introducing the estimations given in FAO and OECD (2008). Product specific changes in prices are reported in Table 4.3. The average increase is about 30 percent. Water is reallocated from agriculture to urban and industrial use in the West region in the urbanization scenario. Simulations involve increasing urban water supply by 30 percent (Scenario 2.a) and 50 percent (Scenario 2.b) with a corresponding reduction in water available for irrigation in this region. Lastly climate change scenario is quantified by a fall in the yields of rain-fed crops by 30 percent (Scenario 3.a) and then by an additional decline in the yields of irrigated crops by 10 percent (Scenario 3.b). The regional yields of both rain-fed and irrigated crops are reduced at varying degrees in the last version of climate change scenario (Scenario 3.c).

Total nominal and real GDP decline, almost in all scenarios, with the exception of the urbanization scenario. The magnitude of the decline in nominal GDP is highest in the climate change scenario: The more severe the climate change, the more severe is the decline. There is a significant decline in rainfed and livestock activities. Value added created by rainfed activities deteriorates as a result of a declining yield in rainfed activities. Livestock production falls due to increasing crop prices and costs in livestock production. However, increasing production in irrigated land compensates for the decline in other sectors.

Value added created by agriculture increases in all scenarios in nominal terms. However, real agricultural value added declines. This implies, that in all three cases the effects working on increasing domestic price dominates the effects working on the cost of production.

Sectoral value added is highly sensitive to the shock given in the climate change scenario when compared with the impact of other scenarios.

Table 4.1. Effects on GDP

			Base Level (1000 TRY)	% Change					
				Sc. 1	Sc. 2a	Sc. 2b	Sc. 3a	Sc. 3b	Sc. 3c
Nominal	at Factor Costs	Total	335,699,820	-0.79	0.12	-0.12	-5.82	-7.00	-5.90
		Agriculture	48,935,094	5.24	1.54	2.04	1.34	1.91	1.63
		Rainfed Agriculture	25,688,482	8.34	4.16	7.34	-6.48	-0.18	2.65
		Irrigated Agricultural	18,001,061	4.58	-1.44	-3.77	28.89	24.20	16.87
		Other Agriculture	5,245,551	-7.68	-1.01	-3.97	-54.92	-64.36	-55.69
		Non-Agricultural	286,764,725	-1.81	-0.13	-0.48	-6.96	-8.42	-7.11
		Services	168,529,416	-1.38	1.36	1.43	-6.86	-8.24	-6.88
		Industry	118,235,309	-2.42	-2.25	-3.21	-7.10	-8.68	-7.43
	at Market Prices		379,686,752	-1.13	0.07	-0.17	-5.56	-6.74	-5.69
Real	at Factor Costs	Total	335,699,820	-0.31	0.25	0.35	-2.66	-3.47	-3.02
		Agriculture	48,935,094	-0.05	-1.66	-3.02	-15.90	-20.02	-17.37
		Rainfed Agriculture	25,688,482	1.34	1.34	2.73	-37.67	-35.03	-27.16
		Irrigated Agricultural	18,001,061	-1.30	-6.04	-11.37	15.60	1.73	-3.19
		Other Agriculture	5,245,551	-2.55	-1.36	-2.55	-17.44	-21.21	-18.13
		Non-Agricultural	286,764,725	-0.35	0.58	0.92	-0.37	-0.59	-0.53
		Services	168,529,416	-0.19	0.08	0.07	-0.29	-0.49	-0.41
		Industry	118,235,309	-0.59	1.28	2.14	-0.47	-0.75	-0.69
	at Market Prices		379,686,752	-0.57	0.32	0.45	-1.94	-2.54	-2.23

Source: Results from TACOGEM-W.

Note: Sc1: Agricultural prices are increased according to FAO and OECD 2008; Sc2a: 30 percent water transfer from urban to rural areas; Sc2b:50 percent water transfer from urban to rural areas; Sc3a: Yield of rainfed crops falls by 30 percent; Sc3b: Yield of rainfed crops falls by 30 percent and irrigated crops falls by 10 percent; Sc3c: Regional yields of all crops falls at various degrees.

Agricultural value added increases in all scenarios. The increase is mainly due to the increase in production in irrigated activities for the climate change scenario, in rainfed activities in the urbanization scenario and in the world price increase scenario. Other agricultural activities deteriorate in all scenarios. The value added of other activities falls as much as 64 percent. Industrial activities also experience a decline of approximately 2 to 9 percent. A change in the non-agricultural value added is also higher in the climate change scenario. The changes in the real value added are milder. Furthermore, the industrial value added increases in real terms within the urbanization scenario.

The comparison of changes in nominal and real GDP and the sectoral value added show that an important account of GDP change is due to adjustment in prices. In real terms, effects are milder, and in the opposite direction.

Table 4.2. Macroeconomic results of simulations

	Base Level[a]	% Change					
		Sc. 1	Sc. 2a	Sc. 2b	Sc. 3a	Sc. 3b	Sc. 3c
Absorption	384,423,455	-0.5	0.3	0.4	-1.9	-2.5	-2.2
Household Consumption	245,160,549	-0.2	1.2	1.7	-1.8	-2.4	-2.1
Investment	75,017,087	-1.7	-2.3	-3.2	-3.8	-5.1	-4.5
Export	98,447,183	-1.4	-0.6	-0.9	-2.1	-2.6	-2.4
Import	103,183,886	-1.0	-0.6	-0.9	-2.0	-2.4	-2.2
PPP Real FX Rate	100	-0.5	0.1		-4.2	-5.0	-4.2
Nominal FX Rate	100	-1.8	-0.1	-0.4	-5.9	-7.1	-6.0
Export Price Index	100	0.9					
Import Price Index	100	0.7					
World Price Index	100	0.8					
Domestic Price Index	100	-0.5	-0.2	-0.4	-1.8	-2.2	-1.9
Consumer Price Index	100						
Terms of Trade	100	0.2					

Source: Results from TACOGEM-W.

Notes: [a] 1000 TRY for GDP accounts. Sc1: Agricultural prices are increased according to FAO and OECD 2008; Sc2a: 30 percent water transfer from urban to rural areas; Sc2b:50 percent water transfer from urban to rural areas; Sc3a: Yield of rainfed crops falls by 30 percent; Sc3b: Yield of rainfed crops falls by 30 percent and irrigated crops falls by 10 percent; Sc3c: Regional yields of all crops falls at various degrees.

For demand side macro variables we can conclude similar results. The change is higher in climate change scenario. Total consumption falls for the first and third scenarios, while increasing in urbanization. However, when water consumption is removed from the scenario, consumption falls for the urbanization scenario as well. For all scenarios, agricultural consumption decreases while the manufacturing goods consumption increases.

4.2 Scenario 1: Increase in World Prices

World agricultural prices began to rise significantly early in 2005 and by June 2008 prices was above historical peaks for almost all agricultural commodities traded internationally (OECD and FAO, 2008). Although a decline in prices is expected in the short run, the average is expected to remain above the mean of last 10 years in the medium term. This increase is expected to be between 20 percent to 80 percent for various agricultural products.

For the change in world prices we follow the estimates given by FAO and OECD (2008) for 2016-2017. The magnitude of price shocks given to the model is depicted in Table 4.3. The average increase is about 30 percent.

Table 4.3. Price Shocks in Scenario 1

Product	Increase in World Price (%)	Product	Increase in World Price (%)
Wheat	48	Fruits	10
Barley	45	Nuts	10
Maize	42	Other crops	45
Other grains	45	Milk	62
Pulses	45	Cattle Meat[2]	19
Sugar beet	27	Other Bovine Meat[2]	23
Raw Cotton[1]	7	Poultry and Eggs	24
Oil seeds	42	Other Animal Prod.	20
Potatoes	10	Other Agricultural Prod.	20
Vegetables	10	Average	30

[1] Ethridge et. al. (2006) and FAPRI (2008)
[2] Estimate for European Union
Source: FAO and OECD (2008), Ethridge et al. (2006) and FAPRI (2008)

Introducing the price shocks from Table 4.3 into the model has two primary effects. First of all, agricultural imports and exports change significantly. Increasing demand for exports will change the equilibrium price and quantities in the goods market. However the magnitude of the effects will be determined by elasticities. Since we employ an Armington structure, an increase in world prices are not reflected directly in domestic prices. Table 4.4 shows the resulting change in production and prices of commodities as a result of the price shocks described in Table 4.5. Price changes are higher for maize, pulses and other animal products. These products have a relatively higher share in agricultural exports and lower Armington elasticities implying a lower substitutability of domestic and imported goods.

Table 4.4. Change in domestic average output prices and composite good supply and domestic production

	Domestic Production		Aggregate Supply		Price	
	Base (1000 Tons)	Change (%)	Base (1000 Tons)	Change (%)	Base	Change (%)
Wheat	19,000	6.53	20,550	-0.56	0.50	4.05
Barley	8,100	1.63	7,974	-0.50	0.35	3.04
Maize	2,800	32.22	4,614	2.88	0.50	8.00
Other grains	758	0.19	782	-3.05	4.75	5.23
Pulses	1,558	20.20	1,356	0.95	1.82	7.05
Tobacco	1,529	-5.15	1,384	-3.91	1.48	3.09
Sugar beet	12,623	-2.90	12,651	-3.01	0.28	2.50
Cotton (raw)	2,295	5.94	2,987	-2.09	1.19	0.59
Oil seeds	2,359	4.20	2,058	-2.85	0.74	4.44
Potatoes	5,300	-1.59	5,179	-1.69	0.54	2.63
Vegetables	24,019	-2.65	23,288	-2.64	0.69	3.30
Fruits	13,221	-2.59	12,096	-2.97	0.89	3.73
Nuts	789	-1.96	570	-3.31	4.80	4.75
Other crops	2,974	-4.06	2,581	-3.76	2.16	4.76
Milk	9,096	-2.43	9,126	-2.65	1.00	0.58
Cattle Meat	5,243	-1.81	5,242	-1.81	1.00	0.72
Other Bovine Meat	2,333	-0.61	2,305	-1.16	1.00	0.52
Poultry and Eggs	3,646	-2.11	3,588	-3.08	1.00	3.91
Other Animal Prod.	2,113	6.84	2,046	-4.45	1.00	9.03
Other Agricultural Prod.	6,213	1.64	6,347	-2.73	1.00	-1.01
Food Production	31,970	-4.03	30,490	-1.69	1.00	2.15
Mining	4,407	-0.92	19,962	-1.00	1.00	-1.85
Consumer Manufac.	101,370	-0.60	77,701	0.36	1.00	-1.61
Int. and Cap. Goods	129,439	-1.19	173,759	-0.75	1.00	-1.71
Electricity and Gas	26,923	-0.12	26,923	-0.12	1.00	-1.24
Water	9,414	-0.03	9,414	-0.03	1.00	-2.25
Construction	46,351	-1.48	46,351	-1.48	1.00	-1.99
Private Services	219,470	-0.34	191,560	-0.11	1.00	-1.44
Government Services	69,195	-0.01	69,195	-0.01	1.00	-0.81

Source: Results from TACOGEM-W.

Domestic production increased significantly in almost all activities as a result of the price shocks. This increase covers the decline in imports and increase in exports. Another interesting result is the connection between agricultural trade and other sectors' production and prices. This effect originates from the household utility maximization, which is the second main driver of the effects of the shock. Income and Urban household consumption declined roughly by 1 percent.

Furthermore there was a 1.7 percent decline in investment spending and a 1.2 percent decline in the intermediate input demand. Thus an increase in world prices of agricultural commodities causes a decline in prices of other commodities that compete for resources.

For these products quantity of supply and price moves in the same direction. This implies a higher export demand for these goods. A comparison of the share of exports and imports in total production, represented in Table 4.5., reveals this fact. The increase in exports is relatively higher for maize, pulses and other animal products while the increase in imports is minimal.

Table 4.5. Percentage change in share of exports and imports in total production

	Export			Import		
	Base	**Sc. 1**	**Base/Sc.1**	**Base**	**Sc. 1**	**Base/Sc.1**
Wheat	0.01	0.02	3.42	8.98	2.63	0.29
Barley	2.32	3.69	1.59	0.93	0.56	0.61
Maize	1.58	2.92	1.85	68.56	35.95	0.52
Other grains	0.07	0.11	1.55	8.17	5.28	0.65
Pulses	11.16	22.19	1.99	0.88	0.32	0.36
Tobacco	24.05	23.45	0.97	14.60	15.21	1.04
Sugar beet	0.00	0.01	1.87	0.22	0.12	0.53
Cotton (raw)	6.97	8.60	1.23	37.26	29.15	0.78
Oil seeds	4.37	5.58	1.28	18.54	14.13	0.76
Potatoes	0.93	1.00	1.07	0.30	0.28	0.94
Vegetables	1.97	2.08	1.06	0.38	0.36	0.94
Fruits	7.09	7.47	1.05	0.64	0.60	0.94
Nuts	19.61	20.34	1.04	0.62	0.58	0.94
Other crops	0.06	0.13	2.10	0.13	0.06	0.48
Milk	0.04	0.07	1.66	0.38	0.23	0.60
Cattle Meat	0.02	0.02	1.29			
Other Bovine Meat	1.24	1.73	1.40	0.01	0.01	0.71
Poultry and Eggs	2.15	2.89	1.35	0.55	0.40	0.73
Other Animal Prod.	14.58	20.14	1.38	11.40	7.16	0.63
Other Agricultural Prod.	3.64	5.52	1.52	5.80	3.66	0.63
Food Production	8.04	6.57	0.82	3.42	4.31	1.26
Mining	18.47	18.49	1.00	371.40	371.04	1.00
Consumer Manufac.	33.13	32.67	0.99	9.79	10.06	1.03
Int. and Cap. Goods	23.00	22.88	0.99	57.24	57.71	1.01
Private Services	12.72	12.52	0.98			

Source: Results from TACOGEM-W.

The net effect of increasing world food prices on household welfare is also controversial. Non-farm households are likely to be adversely affected by increasing food prices. However, increasing export demand has the reverse effect by changing the factor allocation and causing a new equilibrium within the factor markets. Demand for the factors used by agriculture is likely to increase, while factor demand by industrial sectors is expected to decline. The ultimate result will be determined by the calibrated model parameters.

The change in the allocation of factors among activities is given in Table 4.6. Labor employment increases in all activities, except in tobacco production. Increases are as high as 44 percent in maize and 32.5 percent in pulses; which are the sectors most affected by the designated world price change. Land and water employment in maize also increases significantly, at the cost of employment of these factors in the other sectors.

Table 4.6. Percentage change in factor employment

	Labor		**Rainfed Land**		**Irrigated Land**		**Water**	
	Base*	**Sc. 1****	**Base†**	**Sc. 1****	**Base†**	**Sc. 1****	**Base‡**	**Sc. 1****
Wheat	2,662	12.51	8,267	1.95	1,898	3.36	5,133	4.43
Barley	734	7.30	3,165	-3.47				
Maize	344	44.02	458	29.74	128	33.45	738	33.46
Oth. grains	1,367	4.99	629	-5.51	140	-2.28	437	-3.42
Pulses	678	32.50	1,535	18.84				
Tobacco	734	-1.65	219	-11.01				
Sugar beet	1,225	0.24			426	-6.56	3,177	-6.43
Cotton	377	11.19			646	2.85	5,667	2.66
Oil seeds	391	10.53	505	1.02	108	2.54	381	3.36
Potatoes	985	1.68			215	-5.25	999	-4.80
Vegetables	5,731	1.63	3,687	-8.08	826	-6.52	4,187	-5.72
Fruits	4,065	1.79	1,154	-6.65	439	-6.49	2,134	-5.69
Nuts	1,295	2.34	418	-7.30				
Oth. crops	2,242	0.62	202	-9.07	39	-7.43	122	-8.22
Total Agr.	22,831	4.94	20,238	0.00	4,866	0.00	22,975	0.00

Source: Results from TACOGEM-W.
* In terms of labor VA, Million TRY, ** % Change, † 1000 Ha., ‡ Million m^3.

By comparing Table 4.6 with Table 4.4 an important fact is revealed. Labor employment increases despite the fall in production quantities. An important account of factors shifts to the agricultural sector to compensate for the loss in total supply as a result of the increase in import prices.

Since total supply of land and water is fixed in the model, the change reflects the reallocation process as various sectors compete for resources. Factors are shifted to the activities where prices increase as a result of the world price shock. Water use increases in wheat, maize, cotton and oil seeds at the cost of water usage in other sectors.

The change in the wage rate for labor is not as high as the other factors. Prices of other factors increased more in the Southeast and LSCB regions. This shows a higher stress on the resources of these regions as a result of a world price shock.

Table 4.7: Change in factor prices

	Region	Base Level (TRY)	Sc. 1
Labor		1.00	-0.81
Rainfed Land	**West**	0.27	12.29
	Central	0.11	14.44
	East	0.11	13.29
	Southeast	0.23	15.63
	LSCB	0.14	20.33
Irrigated Land	**West**	0.64	8.79
	Central	0.26	8.91
	East	0.27	9.15
	Southeast	0.53	10.45
	LSCB	0.70	12.14
Water	**West**	0.13	12.12
	Central	0.11	9.79
	East	0.05	10.92
	Southeast	0.09	16.69
	LSCB	0.13	22.06
	Urban	0.81	-2.31

Source: Results from TACOGEM-W.

The most important conclusion of this simulation is that change in world prices have significant welfare implications differentiated among urban and rural households. A change in prices brings about a decline in import demand while boosting the export supply. Consequently, domestic prices increase and strike the urban households through consumption while causing an expansion in the income of rural households. Furthermore, increasing agricultural world prices hampers the industrial sector as well. This effect is a result of the direct competition for resources with agriculture, and in intermediate demand for agricultural products that are now relatively more costly. This causes a second wave of problems for urban households by suppressing their income.

4.3 Scenario 2: The Urbanization Scenario

In the early 1950s in Turkey, internal or rural-to-urban migration and urbanization gained momentum with accelerating development and industrialization trends. Migration is defined as ‘residency shifts across geographical regions and/or administrative areas’ (Ünalan, 1998). Such residency shifts may be due to natural, social, economic, or political requisites (Pazarlıoğlu, 1997). According to Akşit (1998), Turkey has experienced internal migration most prominently during the period 1950-1985. Table 4.8 shows that in 1975 the share of the urban population in total population was 42 percent, jumping to 52 percent in 1985, and reaching 65 percent in 2000 (World Bank, World Development Indicators Online). Akşit (ibid.) states that the contribution of internal migration in such population movements is above 50 percent.

Table 4.8.Urban population dynamics in Turkey

	1975	1980	1985	1990	1995	2000	2003
Population growth (annual, %)	2	2	2	2	2	2	2
Urban population (% of total)	42	44	52	59	62	65	66
Urban population growth (annual, %)	4	3	6	5	3	2	2

Source: World Bank WDI Online

According to latest figures from TurkSTAT, migration across different centers has reached 6,662,263 individuals within the period 1995-2000. This implies that during this time frame 11 percent of the total population in Turkey has been on the move from one residential area to another. Figure 4.1 displays the break-down of the migrating population across different centers for this period. One important aspect to mention is that when compared to previous periods, urban-to-rural (city-to-village) migration is gaining relative importance. Urban to rural migration consists of 20 percent of the total during 1995-2000, while this ratio used to be only 13 percent on average during 1980-1990. Rural to rural migration is observed to lose importance progressively from year to year, while urban to urban migration remains to be the principal form of migration, nevertheless showing a slight drop when compared to previous periods.

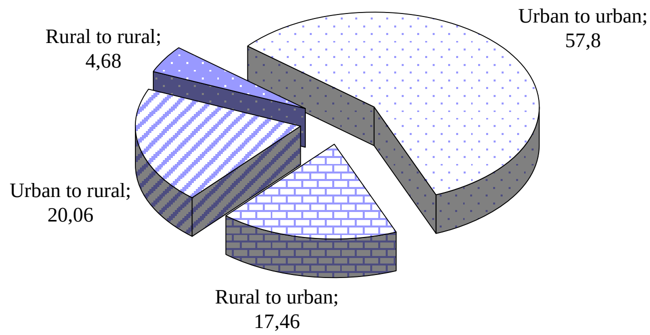

Figure 4.1: In-migration by places of residence (%), 1995-2000

Source: TurkSTAT (2005)

Factors such as a high population growth rate, industrialization, mechanization of agricultural production, shifts in land ownership, inadequate education and health services, a desire to break away from traditional social pressures and feuds in rural areas, as well as increased transportation and communication facilities, can be cited among the most significant factors of internal migration in Turkey (Kahraman, et al., 2002). Indeed, depending on the time period considered, factors that determine the decision to migrate in Turkey, since the 1950s, can be classified as "push", "pull", and "transmitting" (Munro, 1974; İçduygu and Ünalan, 1998). Beginning with the 1950s through the end of the 1960s, migration in Turkey from rural into urban areas can be explained by push factors. Kahraman, et al. (2002) explain that the introduction of new technologies and increased mechanization of agriculture led to a surplus in labor within this sector that migrated into urban areas increasing the laborers hopes for survival and a decent living. Division of land into smaller lots (mainly due to inheritance disputes within families) and thus rendering land less productive, introduction of intensive (modern) techniques in agriculture and finally the inadequacy of educational, health and cultural amenities in rural areas can be considered as other factors that pushed individuals from rural into urban areas.

While migration during the 1950s through the end of 1960s can be explained by push factors described above, migration from the end of 1960s into the 1980s may be accounted for by pull factors (İçduygu and Ünalan, 1998). These pull factors consist of the rural-urban wage gap, concentration of manufacturing and services sectors' work opportunities (Mazumdar, 1998; Kahraman, et al., 2002) and an additionally richer educational and cultural environment as along with more and improved health facilities within urban areas. During the 1980s and 1990s, on the other hand, increased transportation and communication technologies facilitated concentration of goods and services markets in specific urban centers, and thus pulled the population and labor force towards these centers (Kahraman et al., 2002). Table 4.9 shows that internal migration flows have consistently followed an east-to-west pattern over the last 30 years in Turkey, with Istanbul in the lead in terms of receiving in-migration. Istanbul, the largest metropolitan area in Turkey, has reached a population of 10,018,735 (2000 Census of Population) with a 3 percent annual population growth rate, higher than the Turkish average. Turkey's second largest metropolitan area, Ankara, has over 4 million residents and also continues to attract migrants from the rest of the country. The population of Izmir, in the Aegean region, is about 3.4 million for the same census year, and also has shown a higher than average population growth rate of approximately 2.5 percent per annum. Similarly, Antalya, which is the center of a major tourism hub in Turkey, has received substantial migration flows in the past and, with a population of about 2.5 million, has grown roughly 3.6 percent. This is well-above the Turkish average. All metropolitan areas mentioned, i.e. Istanbul, Ankara, Izmir and Antalya, are located in the migrant-receiving western part of the country (see Table 4.9).

Table 4.9. NUTS Level-1 Regions, net internal migration (‰)

	1970–1975	1975–1980	1980–1985	1985–1990	1995–2000
Istanbul	127.46	67.27	56.53	99.86	46.1
Western Marmara	-5.89	-3.78	-1.18	3.08	26.1
Aegean	17.16	21.79	13.37	25.52	22.9
Eastern Marmara	18.99	38.52	27.26	41.95	15.9
Western Anatolia	40.45	9.59	5.65	8.75	15.9
Mediterranean	12.75	12.4	14.87	19.94	0.4
Mid-Anatolian	-25.1	-27.14	-23.9	-49.21	-24.9
Western Black Sea	-22.78	-18.95	-23.09	-46.54	-50.3
Eastern Black Sea	-35.94	-35.58	-36.94	-70.57	-26.1
Northeastern Anatolia	-35.69	-71.54	-58.27	-113.38	-49.8
Mid-eastern Anatolia	-27.95	-43.45	-32.62	-59.01	-33.4
Southeastern Anatolia	-30.81	-30.39	-20.36	-30.33	-36.2

Net internal migration rates do not take into account the migration across provinces within the same region and it is measured as the ratio of net internal migration to mid-period population.
Source: TurkSTAT Website

As large urban areas continue to act as major attraction forces in internal migration, they face the challenge of meeting water demands by the ever-growing urban population. According to a report prepared by the Regional Environment Center (REC), urban water demand accounts for about 15 percent of the total amount of water used in 2003, and is expected to reach an estimated 23 percent by 2030 (REC-Turkey, 2007). Additionally, as large urban centers continue to grow, the industrial sector demand for water is also expected to increase, requiring the metropolitan municipalities to find new water supply sources. In time, although the total water consumption is expected to increase, the sectoral water use allocated to irrigation is expected to decrease in the medium to long run, shifting the resources to domestic and industrial use. In this sense, the share of water used for purposes of irrigation in total water consumption, which is about 74 percent in 2003, is expected to drop to 65 percent by 2030 (ibid.).

Increased urbanization is expected to lead to increased rural-urban competition for water within each region. To simulate increased urbanization and water use in Turkey, we increased the water supply in urban areas in the West region and reduced the irrigation water available for agriculture by the same magnitude, i.e. we reallocated the limited amount of water from agriculture to urban and industrial use in the West region. The main reason for only considering the West region is because the West region in TACOGEM-W covers the rapidly urbanizing metropolitan areas such as Istanbul, Izmir and Antalya. Simulations involve increasing urban water supply by 30 percent (Scenario 2.a) and 50 percent (Scenario 2.b) with a corresponding reduction in water used for irrigation in this region.

As a result of a reallocation of irrigation water to urban use (Scenario 2.a) by 30 percent in the West region, we see a decline in overall production (the sum of both irrigated and rainfed land) of all crops by 0.5 to 3 percent (Table 4.10). We notice that an overall decline in this region plays a very significant role because the West region produces 44 percent of all maize, 73 percent of all tobacco, 59 percent of all oil seeds, 60 percent of all fruits, 64 percent of all vegetables, 34 percent of all nuts, and similarly, 34 percent of all wheat in the country. In particular, we observe the highest decline in maize production, as maize is the most water-intensive crop among all crops considered. As expected, when the water supply in irrigated activities is reduced, a clear drop in production can be seen, and since the factors for production released by irrigated production activities are reallocated into rainfed activities, we would expect an increase in production in rainfed activities.

Most notably, maize and fruit production in irrigated land dropped by 7 percent, production of oil seeds dropped by 6 percent, vegetable production by 6.7 percent, and wheat production by 5 percent. We notice that production increases on rainfed land does not compensate for the drop in production of irrigated crops. As a result, prices in all agricultural activities increase at varying rates, while prices in national non-agricultural activities (except for food manufacturing, electricity, gas and government services) fall at varying rates. Particularly, the price of water as a commodity by urban use fell by 45 percent following the transfer from rural activities in the West region.

Table 4.10. Change in total production quantity

	Unit	Base Level	% Change	
			Sc. 2.a	**Sc. 2.b**
Wheat	Tons	19,000	-1.78	-3.18
Barley	Tons	8,100	-0.52	-1.00
Maize	Tons	2,800	-3.32	-5.76
Other grains	Tons	758	-1.29	-2.33
Pulses	Tons	1,558	-0.68	-1.27
Tobacco	Tons	1,528	-1.72	-3.07
Sugar beet	Tons	12,623	-0.95	-1.87
Cotton (raw)	Tons	2,295	-3.82	-6.97
Oil seeds	Tons	2,359	-1.07	-1.78
Potatoes	Tons	5,300	-0.37	-0.79
Vegetables	Tons	24,018	-1.34	-2.54
Fruits	Tons	13,221	-1.62	-2.76
Nuts	Tons	789	-1.62	-2.88
Other crops	Tons	2,974	-1.06	-2.00
Milk	Tons	9,096	-0.79	-1.47
Cattle Meat	Tons	5,242	-0.33	-0.67
Other Bovine Meat	Tons	2,333	-0.10	-0.23
Food Industry	VA, Million	3,646	-0.19	-0.53
Other Animal Prod.	VA, Million	2,112	-0.77	-1.22
Other Agricultural Prod.	VA, Million	6,212	-1.05	-1.81
Food Production	VA, Million	31,969	-1.40	-2.55
Mining	VA, Million	4,407	0.51	0.64
Consumer Manufac.	VA, Million	101,370	0.19	0.24
Int. and Cap. Goods	VA, Million	129,439	-0.65	-0.90
Electricity and Gas	VA, Million	26,923	-0.04	-0.07
Water	VA, Million	9,413	18.18	30.18
Construction	VA, Million	46,351	-1.84	-2.56
Private Services	VA, Million	219,470	0.20	0.21
Government Services	VA, Million	69,194	-0.06	-0.09

Source: Results from TACOGEM-W.

A production decrease in irrigated land activities, particularly in the West, following a reallocation of irrigation water to urban use, prompts changes in the labor use patterns.

Contraction in irrigated land activities in the West leads to a release of labor from these activities. The amount of labor release is 1.25 percent in tobacco production, followed by 1.69 percent in the production of cotton. Although there is a drop in labor demand in irrigated land activities in the West, alternative activities compete for the labor released from irrigated activities as they experience an increase in labor demand. In fact, we see a slight increase in the wages paid to labor by 1.1 percent as a result of the decrease in irrigation water in the West region. The price of rainfed land rent also increases by 3.7 percent in the West Region. Since water is used only by irrigated activities, a decline in the, water supply accompanied by a drastic increase in water prices, forces the area allocated to irrigated activities to contract. This decreases the price of irrigated land. Furthermore, the price of rainfed land increases because rainfed agriculture enjoys the increase in prices without bearing any cost for the ever increasing water prices. The inter-sectoral transfer of water raises drastically the shadow value of water for irrigation by 70 percent. This adjustment can also be interpreted as a domestic terms of trade effect between irrigated and rainfed land resources (Table 4.11).

Table 4.11. Change in factor prices

	Region	Base Level (TRY)	% Change	
			2.a	2.b
Labor		1.00	1.10	1.18
Rainfed Land	**West**	0.27	3.69	6.65
	Central	0.11	3.30	5.86
	East	0.11	3.08	5.45
	Southeast	0.23	2.84	4.97
	LSCB	0.14	4.03	7.32
Irrigated Land	**West**	0.64	-9.59	-19.06
	Central	0.26	2.79	4.89
	East	0.27	2.93	5.14
	Southeast	0.53	2.13	3.78
	LSCB	0.70	2.60	4.61
Water	**West**	0.13	69.64	160.81
	Central	0.11	4.37	7.63
	East	0.05	4.48	7.87
	Southeast	0.09	2.65	4.88
	LSCB	0.13	3.32	5.96
	Urban	0.81	-47.62	-60.98

Source: Results from TACOGEM-W.

The decrease in agricultural production, and the pursuing domestic price increases, prompt imports to increase and exports to decrease in these activities, holding all else constant. In aggregate, for example, we see decreases in the volume of exports in cotton up to 9.41 percent (Table 4.11). Both cotton and wheat have the highest drop in the value of exports. The decrease in production also implies lower amounts supplied to the domestic economy. Hence, to meet the slightly increasing domestic demand due to slightly increasing domestic factor incomes, quantity of imports rise to some extent. Albeit not as sharp as the fall in exports, all agricultural commodities register increases in volume of imports (Table 4.12). Real urban household consumption rises by 1.2 percent, and rural households in different regions also experience increases in real consumption at varying degrees. For example, while rural households have a 1.1 percent increase, rural households in the Southeast region report a 1.7 percent rise in real consumption. This difference is mainly because of changes in factor incomes across regions. Overall, in Turkey, real household consumption shows an increase of 1.2 percent from the base.

Table 4.12. Change in export quantities

	Quantity			Value		
	Base Level*	% Change Sc. 2.a	Sc. 2.b	Base Level	% Change Sc. 2.a	Sc. 2.b
Wheat	1,292	-7.94	-13.46	645	-8.06	-13.81
Barley	187,648	-2.31	-3.90	66,457	-2.43	-4.28
Maize	44,320	-7.44	-12.79	22,123	-7.56	-13.13
Other grains	522	-4.82	-8.17	2,480	-4.95	-8.53
Pulses	173,938	-3.83	-6.35	316,857	-3.95	-6.72
Tobacco	367,620	-2.50	-4.33	543,589	-2.63	-4.71
Sugar beet	602	-7.16	-11.95	169	-7.28	-12.30
Cotton (raw)	160,025	-9.41	-16.95	189,896	-9.53	-17.28
Oil seeds	103,178	-3.99	-7.09	76,128	-4.12	-7.46
Potatoes	49,458	-2.24	-3.81	26,902	-2.37	-4.20
Vegetables	472,192	-4.10	-7.28	323,523	-4.23	-7.65
Fruits	937,149	-6.55	-11.49	830,093	-6.67	-11.84
Nuts	154,727	-3.65	-6.11	742,803	-3.78	-6.48
Other crops	1,895	-7.30	-12.27	4,096	-7.42	-12.62
Milk	4,034	-1.58	-2.46	4,034	-1.71	-2.85
Cattle Meat	947	-2.23	-3.29	947	-2.36	-3.68
Other Bovine Meat	28,903	-2.12	-2.87	28,903	-2.25	-3.25
Poultry and Eggs	78,240	-2.35	-3.82	78,240	-2.48	-4.20
Other Animal Prod.	307,993	-3.13	-4.51	307,993	-3.26	-4.88
Other Agricultural Prod.	225,957	-1.09	-1.72	225,957	-1.22	-2.11
Food Production	2,571,710	-9.03	-14.94	2,571,710	-9.15	-15.28
Mining	814,195	1.40	1.85	814,195	1.27	1.44
Consumer Manufac.	33,588,689	-0.52	-0.63	33,588,689	-0.65	-1.02
Int. and Cap. Goods	29,770,967	-0.36	-0.43	29,770,967	-0.49	-0.83
Private Services	27,909,783	0.12	0.25	0	0.00	0.00

Source: Results from TACOGEM-W.

** Value added Thousand TRY*

Table 4.13. Import quantity and value

	Quantity			Value		
	Base	% Change		Base	% Change	
	Level*	Sc. 2.a	Sc. 2.b	Level	Sc. 2.a	Sc. 2.b
Wheat	1,707	5.39	9.43	852,991	5.25	9.00
Barley	75	1.38	2.11	26,710	1.24	1.71
Maize	1,920	2.32	4.01	958,308	2.18	3.60
Other grains	62	2.58	4.20	294,479	2.44	3.79
Pulses	14	3.33	5.32	24,903	3.19	4.91
Tobacco	223	-0.44	-0.99	330,050	-0.57	-1.38
Sugar beet	28	5.67	9.32	7,916	5.53	8.89
Cotton (raw)	855	2.72	5.18	1,014,863	2.58	4.77
Oil seeds	437	0.68	1.19	322,682	0.54	0.79
Potatoes	16	1.60	2.45	8,778	1.47	2.04
Vegetables	92	2.46	4.16	63,121	2.32	3.75
Fruits	84	4.05	7.22	74,676	3.92	6.80
Nuts	5	1.68	2.47	23,580	1.54	2.07
Other crops	4	5.40	9.04	8,446	5.26	8.61
Milk	34	0.01	-0.47	34,145	-0.12	-0.87
Poultry and Eggs	20	2.11	3.02	306	1.87	2.15
Other An. Prod.	241	2.47	3.34	20,183	1.98	2.61
Other Agr. Prod.	360	-1.00	-1.89	240,806	2.34	2.93
Food Production	1,092	8.31	14.10	360,165	-1.13	-2.28
Mining	16,369	-0.79	-1.09	1,091,780	8.16	13.65
Consumer Manufac.	9,920	1.62	1.99	16,369,273	-0.92	-1.48
Int. and Cap. Goods	74,091	-1.12	-1.65	9,919,764	1.49	1.59

Source: Results from TACOGEM-W.
** Value added Thousand TRY*

Scenario 2.b entails a 50 percent increase in the urban water supply by decreasing irrigation water by the same amount, creating responses in the economy in the same direction as in Scenario 2.a, but evidently at higher magnitudes.

4.4 Scenario 3: Climate Change Scenario

Climate change is expected to have a considerable impact on agricultural production. Climate change mainly affects agricultural productivity through reduced water availability (or runoff, i.e. the difference between rainfall and evapotranspiration)—both by reduced precipitation and increased temperatures. Most particularly, it has been reported that most of the Near East Region (including Turkey) will have a decrease in water availability of up to 40 mm per year, and that the decrease will increase to 80 mm per year in the Anatolian Plateau.[3] Such water deficit stress can cause a decline in agricultural yields or require higher water use in irrigation to maintain yields (Yano et al., 2007). In arid and semi-arid parts of the world, climate changes could easily aggravate periodic and chronic shortages of water, and most importantly, climate change poses an important threat in developing countries, many of which are located in arid and semi-arid areas (Watson, et al., 1997). Watson et al. (1997) report that these countries are especially vulnerable in the sense that they predominantly rely on single-point systems such as 'bore-holes' or 'isolated reservoirs' for their water sources, and once these primary systems fail to function, there is hardly any substitute system to provide adequate water supply. Additionally, these countries do not possess sufficient technical, financial or management resources to overcome the vulnerability and adjust to shortages and/or take on adaptation measures.

Turkey, which is located in arid Western Asia or the Middle East, is also expected to be significantly affected by climate change (ibid). This region, which already is undergoing serious water shortages, is possibly one of the regions most influenced by climate change. Water shortages caused by climate change may also be a blessing in disguise for these countries as long as they adopt changes in cropping practices and improve efficiency of water use through efficient irrigation systems (ibid.). However, we have already mentioned that these countries are more likely to lack adequate technical, financial, or administrative resources to do so.

Although there are not many studies on the impacts of climate change on food and agricultural production in the Middle East, one projection finds that increases in temperature of up to 3-4^{o}C will lead to a fall in yields of predominant regional crops across the region by 25 to 35 percent with weak carbon fertilization, or 15 to 20 percent with strong carbon fertilization.[4,5] When we examine the annual total rainfall (mm) data for Turkish provinces from the year 1975 in Figures 4.2, 4.3, and 4.4, we see a clear downward trend in annual rainfall and water availability, particularly in Adana (predominantly producing wheat, maize, cotton, soybean, citrus, fruits), Diyarbakir (primarily supplying wheat, barley, pulses, cotton) and Konya (mostly supplying wheat, barley, sugar beet, pulses), which are important agricultural providers in the

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[3] In the Summary Report on Climate Change: Implications for Agriculture in the Near East-29th FAO Regional Conference for the Near East, Cairo, The Arab Republic of Egypt, 1-5 March 2008.

[4] ibid.

[5] The negative effect of increase in temperatures may be compensated by positive effects of increased CO_2 on crop tolerance to water deficit stress (Fuhrer, 2003; Yano, et al., 2007).

country.[6] Furthermore, Türkeş (1996) has observed that for the period 1930-1993, the area-averaged annual rainfall series has been on the decline slightly throughout Turkey, and particularly over the Black Sea and the Mediterranean regions.

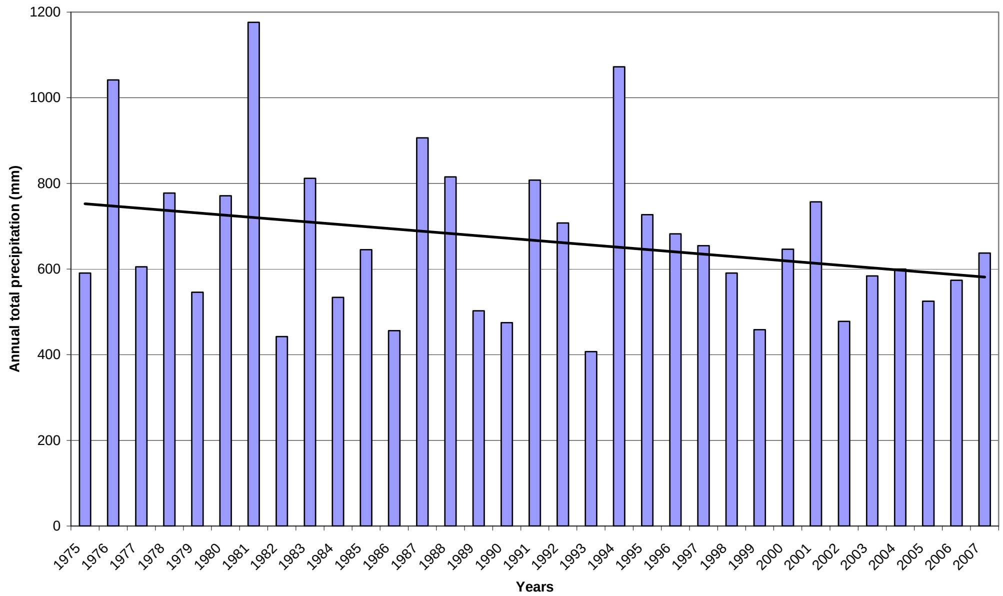

Figure 4.2: Annual total precipitation (mm), Adana

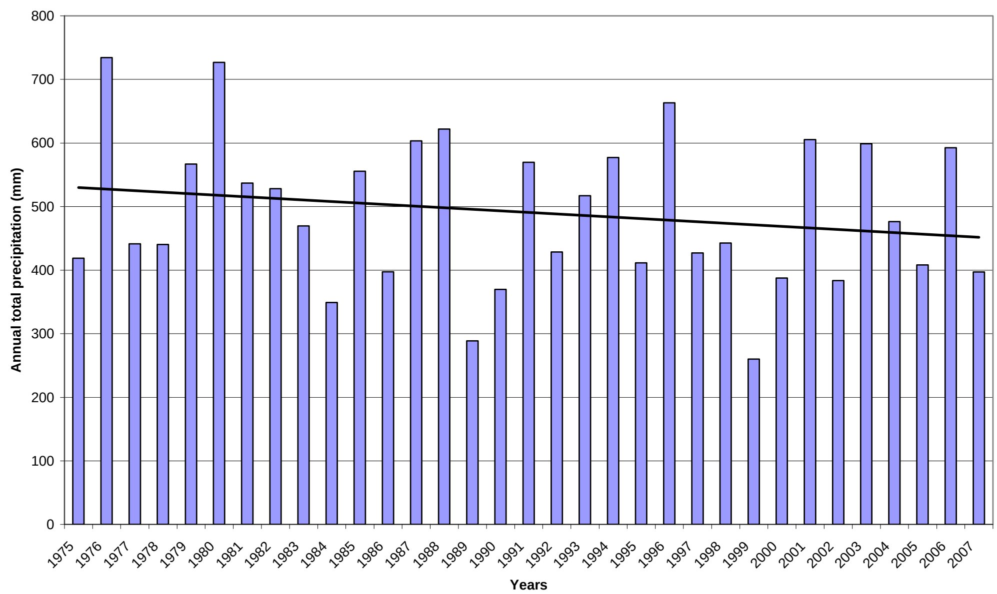

Figure 4.3: Annual total precipitation (mm), Diyarbakır

[6] According to data from Turkish State Meteorological Service Website, http: meteor.gov.tr

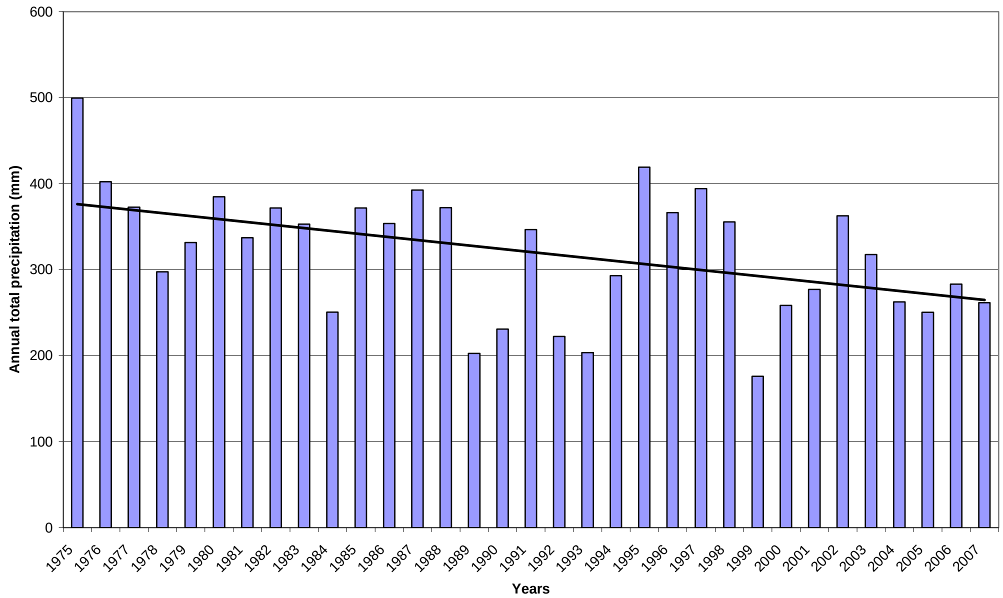

Figure 4.4: Annual total precipitation (mm), Konya

In a simulation study focusing on the effects of climate change on crop growth and irrigation water demand for a wheat-maize cropping sequence in Adana province in Turkey, Yano et al. (2007) find that in the future (simulation period 2070-2079), irrigation water demand in wheat activity will increase due to decreased precipitation in this region. In these simulations, precipitation is expected to decrease up to 163 mm over the period of 1990 to 2100. They also find that with current (base) CO_2 levels and only with increased air temperature of 2.2°C, wheat biomass and grain yield decrease by 24 percent and 12 percent respectively for the same simulation period. However they conclude that doubling the CO_2 levels, combined with an air temperature, rise will result in a decrease in biomass by 4 percent, and an increase in grain yield by 16 percent in the 2070s. For maize, their findings suggest that its biomass and grain yield both decrease by 17 percent and 25 percent respectively, under the same scenario of elevated CO_2 levels and increased air temperature. Hence, ignoring the effects of carbon fertilization, one would expect a clear decline in the yields of these crops.

The impact of climate change on agricultural production in Turkey is first simulated by a fall in rainfed crops' yield by 30 percent (Scenario 3.a) and then by a fall in irrigated crops' yield by 10 percent (Scenario 3.b). Final analysis in the climate change scenario involves reducing the yield in all types of crops at varying degrees, ranging from 0 to 30 percent, depending on whether the crop is rainfed or irrigated, and the region it is produced in.

Under scenario 3.a, we first notice that overall production volume in irrigated crops such as vegetables, other grains (rice, etc.), wheat, oil seeds, fruits, and other crops category rise at varying rates. The highest increase is seen in the other grains category by 34 percent, followed by vegetables with 30 percent. Irrigated wheat activity, on the other hand, increases by 9.63 percent overall. We must mention that the crops named above are modeled as growing on both irrigated and rainfed land. While we observe production volume increases in crops which have activity in both irrigated and rainfed land, the production quantity in crops such as cotton (raw), sugar beet and potatoes, which are only grown on irrigated land, all decrease significantly (Table 4.14.).

Table 4.14. Change in production of irrigated activities

	Base	% Change		
	Level (Tons)	**Sc. 3.a**	**Sc. 3.b**	**Sc. 3.c**
Wheat	7,877	9.63	-4.41	-8.07
Maize	1,355	-1.81	-14.89	-16.02
Other grains	304	33.63	17.10	7.02
Sugar beet	12,622	-8.84	-13.71	-13.76
Cotton (raw)	2,295	-15.99	-23.52	-14.34
Oil seeds	976	19.76	5.11	-5.16
Potatoes	5,300	-5.54	-7.74	-7.90
Vegetables	9,827	29.77	14.50	6.66
Fruits	6,562	13.56	1.60	-3.56
Other crops	1,203	35.19	18.69	8.59

Source: Results from TACOGEM-W.

As a result of the fall in the yields of crops on rainfed land, and as production shifts to irrigated land, the shadow value of irrigation water is expected to rise due to increased competition for water. Particularly, the shadow value (or price) of irrigation water in the Central region increases by 27 percent, in the East region by 26 percent, in the LSCB region by 10.46 percent, and in the Southeast region by a moderate 3.34 percent (Table 4.15). At the base run, 36 percent of all wheat produced in Turkey is produced in the Central region, making up the highest share among all regions. In the Central region, 36 percent of total agricultural land is devoted to wheat activity. Furthermore, wheat is an irrigated crop; 41 percent of all wheat is produced on irrigable land, overall. In that sense, recognizing the significance of wheat production in the

Central region, one can expect to observe a relatively high increase in irrigation water shadow prices in this region.

Table 4.15.Change in factor prices

	Region	Base Level (TRY)	% Change		
			Sc. 3.a	Sc. 3.b	Sc. 3.c
Labor*		1.00	-6.21	-7.13	-5.90
Irrigated Land	**West**	0.64	20.20	15.04	17.19
	Central	0.26	21.06	15.43	0.48
	East	0.27	22.06	16.76	7.65
	Southeast	0.53	13.53	8.67	-3.07
	LSCB	0.70	19.79	14.12	10.74
Rainfed Land	**West**	0.27	-3.63	2.21	11.24
	Central	0.11	0.28	5.69	-0.01
	East	0.11	-1.04	3.95	5.89
	Southeast	0.23	3.79	8.20	2.17
	LSCB	0.14	-3.74	3.49	21.86
Water	**West**	0.13	21.82	15.88	18.85
	Central	0.11	27.14	21.65	0.48
	East	0.05	26.09	20.83	9.60
	Southeast	0.09	3.34	-1.35	-13.82
	LSCB	0.13	10.46	5.54	2.25
	Urban	0.81	-7.31	-9.27	-7.88

Source: Results from TACOGEM-W.
**Labor employment is taken as value added created by labor*

Employment of irrigated land increases for wheat, vegetables and fruits, and crops classified as other grains such as rice. This is due to the shift from rainfed land in these activities towards irrigated land as an alternative. Employment of irrigated land in sugar beet, cotton, potatoes and maize production fall at different rates. We mentioned sugar beet, cotton and potatoes are grown only on irrigated land. As production of all crops shifts from rainfed land to irrigated land due to the yield shock in rainfed activity, the price of irrigated land increases in all regions at rates ranging from 13 to 30 percent. With this increase in the price of irrigated land, a drop in employment in irrigated-land-only activities can be expected.

As can be inferred from the discussion above, production volume in all rainfed crop activities drop at various rates. For example, production of fruits in rainfed land drops by 39 percent, while production of oil seeds drop by 36 percent from the base as a result of the 30 percent drop in yield. Overall, considering the sum of both irrigated and rainfed land production activity, we observe a fall in volume of production in all crops. Moreover, production in livestock and national non-agricultural activities also declines.

For example, food manufacturing contracts by 13 percent as there is a reduction in production of intermediate goods in this sector. As a result of the contraction in domestic production, import volume in almost all crops increases except for raw cotton, which experiences a fall in production and a rise in domestic prices. The most significant increase in import volume is seen in other grains with 65 percent as well as an increase in nuts by 45 percent. It is also important to note that manufactured food imports rise by 85 percent in volume. Export volume, on the other hand, decreases significantly following the fall in production in agriculture and an increase in domestic commodity prices.

We must also note that urban household's real consumption decreases by about 3.3 percent, while that of rural households in all regions increases by 4 percent except in the East with a 1.6 percent increase (Table 4.16). We can attribute this disparity in rural and urban household response to differences in sources of income of these household types, and also the composition of consumption expenditures. Urban households earn about 40 percent of the total income due to labor, and the rest from capital, while rural households have income from land and water resources as well. While there is a clear drop in labor and capital income overall, there is a rise in rents to both irrigated and rainfed land, and a slight increase in the water factor income in the West and Central regions (which inhabit a large share of rural households). Nevertheless, there is a significant decline in real GDP by about 6 percent as a result of the fall in yields in rainfed crops by 30 percent simulating a shortage of water caused by climate change.

Table 4.16. Change in disaggregated real household consumption

	Base Level (Million TRY)	**% Change**		
		Sc. 3.a	**Sc. 3.b**	**Sc. 3.c**
Urban HH	192,526	-3.30	-4.00	-3.50
West Rural	28,136	4.10	4.50	5.80
Central Rural	11,422	3.70	3.90	-0.30
East Rural	8,662	1.60	1.50	0.60
Southeast Rural	2,450	2.40	2.00	-3.90
LSCB Rural	1,965	3.90	2.90	2.50
Rural Total	52,635	15.70	14.80	4.70
Turkey	245,161	-1.80	-2.40	-2.10

Source: Results from TACOGEM-W.

Considering Scenario 3.b, in which the crop yield in irrigated activities are reduced by 10 percent, in addition to the 30 percent reduction in rainfed activities, the changes in the production volume of irrigated crops are much less pronounced than those in Scenario 3.a. For example, production quantity in wheat declines by 20 percent compared to 16 percent. An increase in irrigated fruit activity becomes insignificant. We further notice that the response in cotton (raw), sugar beet and potatoes production volume is stronger than that in the previous scenario: there is an additional 10 to 15 percentage point decline in the production of these crops. In this scenario, the changes in the water shadow price and irrigated land price are not as high as those in the former scenario. This is because there is not as much competition for these inputs as before, simply due to the fall in yields and the pursuing fall in production volumes. In all crops, a change in water consumption from the base is smaller than that in the first scenario. As in the first scenario, the import volume of all crops increases and the export volume decreases following a rise in commodity prices, however these changes occur at higher magnitudes. The fall in real GDP is also higher by 3.47 percent.

5 Conclusions, Policy Implications, and Future Research Agenda

This study investigated the economy-wide effects of two external shocks, namely a permanent increase in the world prices of agricultural commodities and the climate change, along with the impact of the domestic reallocation of water between agricultural and non-agricultural use. It was also recognized that because of spatial heterogeneity of the climate, the simulated scenarios have differential impact on the agricultural production and hence on the allocation of factors of production including water.

Table 5.1 presents the simulated changes of some selected macroeconomic variables in all scenarios.

Table 5.1. Summary Impact Matrix

	Sc. 1	Sc. 2a	Sc. 2b	Sc. 3a	Sc. 3b	Sc. 3c
Absorption	⇓	⇑	⇓	⇓⇓	⇓⇓⇓	⇓⇓
Household Consumption	⇓	⇑	⇑	⇓⇓	⇓⇓	⇓⇓
Investment	⇓⇓	⇓	⇓⇓	⇓⇓⇓	⇓⇓⇓	⇓⇓⇓
Government Consumption	⇓	⇑	⇑	⇓⇓⇓	⇓⇓⇓	⇓⇓
GDP at Market Prices	⇓	⇑	⇓	⇓⇓	⇓⇓⇓	⇓⇓
Net Income Tax	⇓⇓	⇓	⇓	⇓⇓	⇓⇓	⇓⇓
GDP at Factor Costs	⇓	⇑	⇓	⇓⇓	⇓⇓⇓	⇓⇓
Total Exports	⇓	⇓	⇓	⇓⇓⇓	⇓⇓⇓	⇓⇓⇓
Total Imports	⇓	⇓	⇓	⇓⇓⇓	⇓⇓⇓	⇓⇓⇓
Agricultural Exports	⇑⇑⇑	⇓⇓	⇓⇓⇓	⇓⇓⇓	⇓⇓⇓	⇓⇓⇓
Agricultural Imports	⇓⇓⇓	⇑	⇑⇑	⇑⇑⇑	⇑⇑⇑	⇑⇑⇑

Note: Sc.1: World price increase; Sc. 2: Rural-urban water transfer; Sc. 3: Climate change.

The highest effects on major macroeconomic indicators occurs in the climate change simulations. Nominal GDP declines drastically, but the real impact is limited. The changes are relatively smaller in the world price increase scenario when compared to all climate simulations. This situation points out the importance of the climate change in the performance of the overall economy. It is obvious that the impact of the climate change will not only be confined to the agricultural sector. Through the interactions with the rest of the economy, the negative impact of the climate change will be amplified. Irrigation is considered the most important adaptation measure to ease the negative impact of climate change, especially on farmers' income. Warming is also expected to affect the availability of water resources. This aspect of the climate change is not incorporated in these simulations. Hence, the climate change adaptation policies incorporating water and land management should be given priority.

An increase in the world prices is expected to decrease all selected macroeconomic indicators, except the agricultural exports. As a result of the price increase the competitiveness of the agricultural sector improves with a high increase in the agricultural exports and almost comparable decrease in the agricultural imports. The accompanied rise in domestic prices strikes urban households through consumption while causing an expansion in the income of rural households. Increasing world prices hampers non-agricultural sectors as well. This further suppresses the income of rural households.

As a result of the transfer of water from rural to urban areas, overall production of all crops decline. Although the production on the rainfed land increases, the production on the irrigated land declines, most notably production of maize and fruits. The decrease in the agricultural production, coupled with the domestic price increase, is further reflected in the net trade. Agricultural imports increase with a higher decline in agricultural exports.

Turkey has been fortunate in its endowment of water resources. However, the demand of water is growing rapidly. The pressure on usable water resources is predicted to increase with the rapid pace of industrialization and urbanization. Scarcity of water in some regions has already started to hamper agricultural production. Over-abstraction of groundwater in the Central Region and over-use of surface water in the West have affected not only the availability of water, but also degraded its quality with serious environmental impact. The response of the governments so far has been focused on building additional infrastructure to release the constraints on water availability. Shifting the irrigation pricing method to promote efficient use of water has never been considered as an alternative to the current pricing method which consists of a per area based operation and maintenance charge. Seven river basins (out of 26), mostly in the West, are already in a serious state of water shortage, with abstractions exceeding 200 percent of the annual renewable resource (World Bank, 2007). If all of the 8.5 million hectares of the “economically irrigable” area is developed, the World Bank (2007) found that almost 18 basins will face serious water shortages. This situation raises serious doubts about the sustainability of the prevailing policies in the irrigation sector.

The results of the simulations further prove deficiency in the currently implemented approach of supply management and the pricing policy in the irrigation sector. The pressure on irrigation water augments in all scenarios. The results of all simulations indicate that the shadow prices for irrigation water increase in all regions, except in the Southeast Region that has a higher impact case in the climate change scenario. Hence, it is necessary to achieve more efficient use of irrigation water which requires not only the promotion of water saving irrigation techniques, but serious consideration should be given to fit the demand for water to meet the supply.

Although the results of the model simulations are rich, it is possible to further improve the model structure. The priority should be given to incorporate the heterogeneous labor structure in the model. The regions can be further disaggregated to NUTS-I level. Further disaggregation of food manufacturing and other agriculture related industries, such as textiles, are necessary to ameliorate the inter-sectoral interactions. Sooner or later Turkey may be tempted by the biofuels frenzy, hence making it necessary to have a detailed energy sector. One valuable extension can be separating rural and urban households according to income groups. This would allow analysis of welfare distribution that the model currently lacks. Structural enhancements will improve the performance of the model, i.e. nested structure in production, especially for irrigated land and water. Another enhancement could be transforming the model into a recursive dynamic one that provides the adjustment paths for external and policy shocks.

This work has indicated also that future policy dialogue among the World Bank, the Government of Turkey, and local institutions is necessary. Water stress in Turkey is predicted to increase with demographic changes and unfavorable global climatic and economic conditions. Fast implementation of necessary policy measures at all levels will achieve more efficient use of public resources and water. The stock of planned or uncompleted irrigation sector projects remains large compared to the financial resources allocated for their execution (SPO, 2008). Priority should be given to better use of existing water infrastructure and proper ranking of the unfinished projects. The first one requires improvement in irrigation management practices. More resources can be allocated to restrict water losses from irrigation infrastructure, starting from the high evaporation regions. There have been improvements in adopting more efficient water application technologies induced by government subsidies. The uptake of these technologies by irrigators can be further increased by shifting towards volumetric pricing practices. SPO (2008) points out the importance of increasing the efficiency in the use of irrigation water by the determination of irrigation fees proportional to the actual amount used.

The main issues arising from this study, namely water pricing and subsidies, water savings irrigation techniques, crop diversification (possibly linked to EU accession requirements), and stabilization of over-exploited aquifers, have long been on the policy agenda of international development agencies such as the World Bank and of the Government of Turkey. The analytical framework proposed in this study could be used to further engage the government with the World Bank on these matters.

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Appendix A: Additional Tables

Table A.1. NUTS Regions

Level-1	Level-2		Level-1	Level-2		Level-1	Level-2	
İstanbul			**Mediterranean**					
	İstanbul	İstanbul		Antalya	Antalya	**Northeastern Anatolian**	Erzurum	Erzurum
Marmara					Isparta			Erzincan
	Tekirdağ	Tekirdağ			Burdur			Bayburt
		Edirne		Adana	Adana		Ağrı	Ağrı
		Kırklareli			Mersin			Kars
	Balıkesir	Balikesir		Hatay	Hatay			Iğdır
		Çanakkale			aş			Ardahan
					Osmaniye			
Aegean			**Mid-Anatolian**			**Mideastern Anatolian**		
	Izmir	Izmir		Kırıkkale	Kırıkkale		Malatya	Malatya
	Aydın	Aydın			Aksaray			Elazığ
		Denizli			Niğde			Bingöl
		Muğla			Nevşehir			Tunceli
	Manisa	Manisa			Kırşehir		Van	Van
		Afyon		Kayseri	Kayseri			Muş
		Kütahya			Sivas			Bitlis
		Uşak			Yozgat			Hakkâri
Eastern Marmara			**Western Black Sea**			**Southeastern Anatolian**		
	Bursa	Bursa		Zonguldak	Zonguldak		Gaziantep	Gaziantep
		Eskişehir			Karabük			Adıyaman
		Bilecik			Bartın			Kilis
	Kocaeli	Kocaeli		Kastamonu	Kastamonu		Şanlıurfa	Şanlıurfa
		Sakarya			Çankırı			Diyarbakır
		Düzce			Sinop		Mardin	Mardin
		Bolu		Samsun	Samsun			Batman
		Yalova			Tokat			Şırnak
Western Anatolian					Çorum			Siirt
	Ankara	Ankara			Amasya			
	Konya	Konya	**Eastern Black Sea**					
		Karaman		Trabzon	Trabzon			
					Ordu			
					Giresun			
					Rize			
					Artvin			
					Gümüşhane			

Table A.2. Model Regions

Region in SAM	**Region as given in NUTS-1**
West	İstanbul
	W. Marmara
	E. Marmara
	Aegean
	Mediterranean
Central	Western Anatolian
	Mid-Anatolian
	Western Black Sea
East	North Eastern Anatolian
	Mid-eastern Anatolian
	Eastern Black Sea
Southeastern Anatolian	Southeastern Anatolian
Lower Seyhan-Ceyhan Basin (LSCB)	Adana, Osmaniye provinces

Table A.3. Aggregated SAM for Turkey, 2003 (Billion TL)

	Agriculture	Ind.&Serv.	Agriculture	Ind.&Serv.	Labor	Capital	Private	Government	S/I	ROW	Totals
Agriculture			80.999.936,15								80.999.936
Ind.&Serv.				527.683.706							527.683.706
Agriculture	10.108.704,66	21.572.920,17					40.396.276	1.914.811	125.602	3.810.939	77.929.252
Ind.&Serv.	20.017.847,81	227.178.725,29					204.689.173	42.277.658	82.197.436	94.685.399	671.046.239
Labor	20.259.707,62	107.757.927,81									128.017.635
Capital	28.671.944,56	140.881.848,35									169.553.793
Private					104.425.155	139.043.206		113.247.686		7.886.043	364.602.090
Government	1.941.731,53	30.292.284,72	- 6.958.631,06	36.916.113	23.592.480	30.510.587	28.370.862				144.665.427
S/I							86.801.914	- 19.398.942		14.920.067	82.323.039
ROW			3.887.947,18	106.446.420			4.343.866	6.624.215			121.302.448
											-
Totals	80.999.936	527.683.706	77.929.252	671.046.239	128.017.635	169.553.793	364.602.090	144.665.427	82.323.039	121.302.448	

Appendix B: The Algebraic Structure of the CGE Model

Prices

The price block of the equations system includes definitions of the endogenous prices, exogenous prices as well as the links between them (world price of imports, f.o.b. price of exports, exchange rates), and other non-price variables in the system. In this system,

Marketed output value = value of domestic sales + value of exports

or,

$$PX_c QX_c = PDS_c QD_c + PE_c QE_c$$

where, $c \in C$, and C is the set of commodities. Here, PE_c is the export price of commodity c, and is measured in TRL, given as $PE_c = pwe_c(1 - te_c)EXR$, where pwe_c is the f.o.b. price of exports (in foreign currency units), te_c is the commodity *c* export tax rate, and *EXR* is the exchange rate (measured in local currency per foreign currency). Measured in TRL, import prices in the system are defined as $PM_c = pwm_c(1 + tm_c)EXR$ where pwm_c is the world price of imports (in foreign currency), and tm_c is the commodity *c* import tariff rate.

In the system, composite price of commodity *c*, PQ_c can be derived from the Absorbtion equation given by

$$PQ_c(1 - tq_c)QQ_c = PD_c QD_c + PM_c QM_c$$

where tq_c represents the sales tax rate on commodity *c*.

Lastly, the value added price in activity $a \in A$, where *A* is the set of activities, can be found as

$$PVA_a = PA_a(1 - ta_a)\frac{QA_a}{QVA_a} - PINTA_a \frac{QINTA_a}{QVA_a}$$

where PA_a is the activity price, ta_c is the rate of tax on producer in activity *a*, $PINTA_a$ is the intermediate input price used in activity *a*, and $QINTA_a$ is the aggregate intermediate input use in activity *a*. The value added price is derived from the zero profit condition given as

$$PA_a(1 - ta_a)QA_a = PVA_a QVA_a + PINTA_a QINTA_a$$

Production and Trade

The production and trade block includes three main categories:

a) Domestic production and input use;

b) The allocation of domestic production to domestic sales and exports;

c) The aggregation of supply to the domestic market (from imports and domestic output sold domestically).

In production, each of the activities are assumed to maximize profits subject to their technology taking prices in their output and factors of production as given. Technology of each activity (sector) $a \in A$ is defined by a Constant Elasticity of Substitution (CES) function in the quantities of value added and the aggregate intermediate input use (production function at the first level of activity):

$$QA_a = \alpha_a^a \left[\delta_a^a QVA_a^{-\rho_a^a} + (1-\delta_a^a) QINTA_a^{-\rho_a^a}\right]^{-1/\rho_a^a}$$

where the value added in activity a is defined by a CES production function:

$$QVA_a = \alpha_a^{va} \left(\sum_{f \in F} \delta_{fa}^{va} QF_{fa}^{-\rho_a^{va}}\right)^{-1/\rho_a^{va}}$$

in which QF_{fa} denotes the quantity demanded for factor *f* in activity *a*. Defining the technology in activity a by a CES technology, the optimal value added-intermediate input ratio can be obtained as

$$\frac{QVA_a}{QINTA_a} = \left[\frac{PINTA_a}{PVA_a} \frac{\delta_a^a}{1-\delta_a^a}\right]^{-\frac{1}{1+\rho_a^a}}$$

Given the profit maximizing behavior in each of the activities, factor demand functions are determined by the rule

Marginal cost of factor = Marginal revenue product of factor

Then,

$$WF_f \, x WDIST_{fa} = PVA_a QVA_a \left(\sum \delta_{fa}^{va} QF_f^{-\rho_a^{va}}\right)^{-1} \delta_{fa}^{va} QF_f^{-\rho_a^{va}-1}$$

Here, the marginal revenue product of labor is given by the product times the marginal product of labor. Also in the condition above, WF_f is the factor f price, and $WDIST_{fa}$ is the factor market distortion variable of factor *f* in each activity *a*.

The total cost of producing quantity QA_a is

$$TC_a = \underbrace{PVA_a QVA_a}_{\text{Total factor cost}} + \underbrace{PINTA_a QINTA_a}_{\text{Intermediate input costs}} + PTAX_a + \underbrace{WCH_a}_{\text{Water charge}}$$

And, $PTAX_a$ is the total production tax collected from sector a with activity a. In activity a, total receipts net of taxes must be equal to total cost, or,

$$PA_a QA_a - PTAX_a - WCH_a = PVA_a QVA_a + PINTA_a QINTA_a$$
$$PA_a QA_a (1 - ptax_a) - WCH_a = PVA_a QVA_a + PINTA_a QINTA_a$$

where $ptax_a$ is the production tax rate in activity a. Water charges are collected by the WUA's in regions where field crop activities are irrigated.

The output transformation function is of Constant Elasticity of Transformation (CET) form:

$$QX_c = \alpha_c^t \left[\delta_c^t QE_c^{\rho_c^t} + (1-\delta_c^t) QD_c^{\rho_c^t} \right]^{1/\rho_c^t}$$

Here, aggregate domestic output is allocated to domestic use (QD_c) and to exports (QE_c), that is, this equation provides information about the distribution of marketed output according to its destination.

Maximizing producer profits subject to the output transformation function, the optimal mix between exports and domestic sales can be obtained as such:

$$\frac{QE_c}{QD_c} = \left(\frac{PE_c}{PDS_c} x \frac{1-\delta_c^t}{\delta_c^t} \right)^{\frac{1}{1-\rho_c^t}}$$

Imports of commodity *c* and its domestic production sold domestically are imperfect substitutes, and this characteristic is summarized by the following aggregation function in Armington form (i.e. ‘the composite supply function’):

$$QQ_c = \alpha_c^q \left[\delta_c^q QM_c^{-\rho_c^q} + (1-\delta_c^q) QD_c^{-\rho_c^q} \right]^{-\frac{1}{\rho_c^q}}$$

Minimizing producer costs subject to the composite supply function, we obtain the optimal mix between imports and domestic demand:

$$\frac{QM_c}{QD_c} = \left(\frac{PDD_c}{PM_c} x \frac{\delta_c^q}{1-\delta_c^q} \right)^{\frac{1}{1-\rho_c^q}}$$

Institutions

In the institutions block of the system, we specify the income sources and the consumption behavior of the main actors in the model, namely the households, the government, and the Water User Associations.

All labor, land and capital factor income is earned by households, Water User Associations collect water charges on water use in irrigated agriculture, and via the government, and these water charges are then redistributed to rural households as transfers (*WPAY*). Household income also is due to transfers from government and transfers from the rest of the world:

$$YIF_h = \sum_{f \in EF} YIF_{h,f} + trnsfr + WPAY + trnsfr(row)$$

Household consumption expenditures are then given by

$$EH_h = YI_h - Savings - \text{Direct taxes}$$

Household consumption demand for commodity c is in the form of a fixed share of total expenditures

$$QH_{h,c} = \beta_{h,c} \frac{EH_h}{PQ_c}$$

Government revenue is derived from direct (factor) taxes, production taxes, import tariffs, exports taxes and sales taxes, that is,

$$YG = \sum_{f} tf_f YF_f + \sum_{a \in A} ta_a PA_a QA_a + \sum_{c \in CM} tm_c \, pwm_c QM_c EXR + \sum_{c \in CE} te_c \, pwe_c QE_c EXR$$
$$+ \sum_{c \in C} tq_c PQ_c QQ_c$$

Here, YF_f is factor f income, *CM* is the set of imported commodities, and *CE* is the set of exported commodities, both of which are a subset of the commodity set, *C*. Government expenditures are

$$EG = \sum_{c} PQ_c QG_c$$

Accordingly, government savings are $GSAV = YG - EG$. Government consumption of commodity *c* (excluding public services) is given by

$$QG_c = \eta_c \frac{EG}{PQ_c}$$

Equilibrium Conditions

The last stage of the model specification involves the statement of equilibrium conditions. Each commodity market clears in the sense that each commodity is demanded either for private consumption, government consumption, investment, or for use as an intermediate good:

$$QQ_c = \sum_{h \in H} QH_{c,h} + QG_c + QINV_c + \sum_{a \in A} QINTA_{c,a}$$

In the economy, there is no unemployment, and all factor markets clear in the sense that at given factor prices, factor demand is equal to available factor supply:

$$\sum_{a \in A} QF_{f,a} = \overline{QSF_f}$$

where $\overline{QSF}_f$ is the exogenously fixed supply of factor *f*.

The closure rule for the savings-investment balance (as per Walras' Law) in this system is given by

$$PSAV + GSAV + EXR \times \overline{FSAV} = PINV$$

where, $\overline{FSAV}$ is the foreign savings, and in equilibrium, is equal to the CA balance (deficit or surplus):

Appendix C: The Algebraic Structure of the Farm Model

Resource and PMP duals constrained by PMP calibration constraints.

We assume that $\varepsilon = 0.001$

$$\sum_i (RR_{ij} * LX_i) \le RHS_j \qquad \forall \text{ resource } j \quad \text{[Resource Constraint]}^{7}$$

where RHS_j is resource constraints[8], RR_{ij} is Leontieff coefficients and is given by

$$RR_{ij} = \frac{X_{ij}}{X_{i,"LAND"}}$$

$$LX_i \le X_{i,"LAND"} * 1.0001 \qquad \forall \text{ Activity process } i \quad \text{[Calibration Constraint]}$$

where LX_i is hectares planted variable X_{ij} is base year resource use ($X_{i,"LAND"}$ is base year land use)

$$\sum_i \left[(V_i * YB_i - CL_i) * LX_i\right] = LINPROF \qquad \text{[Lprofit constraint]}$$

where V_i is price per unit of output (2003 TRY per ton), YB_i is average yields (Tons per ha) CL_i is linear cost and it is given as $CL_i = \sum_j C_{ij} * RR_{ij}$ where C_{ij} is resource variable costs and RR_{ij} is Leontieff coefficients and is given by

$$RR_{ij} = \frac{X_{ij}}{X_{i,"LAND"}}$$

LX_i is hectares planted variable, $LINPROF$ is LP profit variable. Then

```
PROBLEM:         MAX LINPROF
                 Subject to
                       Resource Constraint
                       Calibration Constraint
```

CES Input Share Parameters

Parameters are calculated from the recursive equations derived in the appendix of Howitt (1995)[9]

7 *j=LAND, LABOR, TRAC, SEED, NITRO, PHOSPH, WATER.*
p(j)= LABOR, TRAC, SEED, NITRO, PHOSPH, WATER
r(j)=LAND

8 *j=LAND, LABOR, TRAC, SEED, NITRO, PHOSPH, WATER.*

9 Note - this code ıs written ın a general way that adjusts for any changes ın the number of crops, regions or inputs defined in the sets at the start of the program

$$BETA_{i,j=1} = \frac{1}{\sum\limits_{\substack{p \\ X_{ip} \neq 0}} \left(\frac{CS_{ip}}{CS_{ij}}\right)\left(\frac{X_{ij}}{X_{ip}}\right)^{THETA} + 1}$$

where $THETA = -\frac{1}{SUB}$, and SUB is elasticity of substitution, CS_{ip} is factor cost plus opportunity cost and

$$CS_{ij} = C_{ij} + OP_j + LA_{ij}$$
$$OP_j = RESOURCE.M_j$$
$$OP_{"LAND"} = RESOURCE.M_j - ADJ$$
$$LA_{i,"LAND"} = CALIB.M_i + ADJ$$

X_{ij} is base year resource use

$$BETA_{i,1<j<7\, and\, X_{ij} \neq 0} = \left(\sum_r BETA_{ir}\right)\left(\frac{CS_{ij}}{\sum_r CS_{ir}}\right)\left(\frac{\sum_r X_{ir}}{X_{ij}}\right)^{THETA}$$

CES Scale Paramter (α_i)

CES scale parameter is calculated using the share parameters and total output[10].

$$CN_i = \frac{TO_i}{\left[\sum_j \left(BETA_{ij} * \left(X_{ij} + 0.001\right)^{\frac{SUB-1}{SUB}}\right)\right]^{\frac{SUB}{SUB-1}}}$$

where TO_i is total output and given by $TO_i = YB_i * X_{i,"LAND"}$. Here YB_i is average yields (Tons per ha) and X_{ij} is base year resource use ($X_{i,"LAND"}$ is base year cultivated area for crop *i*) and *SUB* is elasticity of substitution

PMP Cost function coefficients

PMP cost function coefficients are calculated based on Howitt (1995)

$ALPH_{ij} = C_{ij} - LA_{ij}$	Intercept of cost function
$GAM_{\substack{ij \\ where\, LA_{ij} \neq 0}} = \frac{2 * LA_{ij}}{X_{ij}}$	Slope of cost function

[10] $y_i = \alpha_i \left(\beta_{i1} X_{i1}^{\gamma_i} + \beta_{i2} X_{i2}^{\gamma_i} + \beta_{i3} X_{i3}^{\gamma_i}\right)^{\frac{1}{\gamma_i}}$

where C_{ij} is resource variable costs, $LA_{i,"LAND"} = CALIB.M_i + ADJ$ and $ADJ = 0.25 RESOURCE.M_{"LAND"}$

CES Programming Solution for the Base Year

$$\sum_i XN_{ij} \le RHS_j \qquad \forall j \qquad \text{[Input Constraint]}$$

$$TPROFIT = \sum_i V_i * \left(CN_i * \left[\sum_j BETA_{ij} * \left(XN_{ij} + 0.0001 \right) \right]^{\frac{SUB-1}{SUB}} \right)^{\frac{SUB}{SUB-1}}$$

$$- \sum_i \sum_j \left[ALPH_{ij} * XN_{ij} + 0.5 * GAM_{ij} * XN_{ij}^2 \right] \qquad \text{[Profit]}$$